

**ASSESSMENT AND PRIORITIZATION OF  
STREAMS IN BACK RIVER, JONES FALLS,  
BRETON BAY, BIRD RIVER, LOWER POCOMOKE  
RIVER, AND SOUTH RIVER WATERSHEDS IN  
NEED OF RESTORATION AND PROTECTION**



**CHESAPEAKE BAY AND  
WATERSHED PROGRAMS  
MONITORING AND  
NON-TIDAL ASSESSMENT  
CBWP-MANTA-EA-03-10**





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**Final Data Report:**

**Assessment and Prioritization of Streams in Back River, Jones Falls, Breton Bay, Bird River,  
Lower Pocomoke River, and South River Watersheds in Need of Restoration and Protection**



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## **Introduction**

This work was completed by the Maryland Department of Natural Resources (DNR), Resource Assessment Service, Monitoring and Non-Tidal Assessment Division under award number NA17OZ2337.

In response to former President Clinton's Clean Water Action Plan, Maryland completed its first Unified Watershed Assessment (UWA) during 1998. The UWA identified Maryland watersheds (8-digit) most in need of restoration and protection. This annual report uses results from the Maryland Biological Stream Survey (MBSS) to assist in the prioritization of specific areas within the 8-digit priority watersheds identified by the UWA. This finer scale analysis can be used to target limited funds within each watershed so that they provide the maximum benefit to stream resources. This report also provides a list of the probable stressors to biota in these specific areas. Knowledge of the stressors to a given stream system can be used to focus restoration efforts on parameters that should provide the greatest likelihood for success.

This report covers six watersheds: Back River, Jones Falls, Breton Bay, South River, Bird River, and the Lower Pocomoke River. According to the UWA, all of these watersheds show signs of stress and have streams that are in need of restoration. They may however contain sensitive natural resources as well which are in need of protection.

The goal of this report is to provide guidance for targeting resource management initiatives within each of these UWA priority watersheds. This targeting includes the identification of areas most in need of restoration and protection as well as a diagnosis of probable stressors to ecological resources in areas where restoration is needed. Although this information pertains exclusively to ecological resources, it is hoped that it will be considered as part of a comprehensive restoration and protection plan.

## **Methods**

A total of 276 sampling sites were used to characterize stream conditions and identify potential stressors to stream resources in the Back River, Jones Falls, Breton Bay, South River, Bird River, and the Lower Pocomoke River watersheds (Figures 1-6). Fish, benthic macroinvertebrate, herpetofauna, physical habitat, chemical, and land use data were collected from a total of 145 randomly selected sampling sites as part of the Maryland Biological Stream Survey conducted by DNR between 1994 and 2001. Benthic macroinvertebrate data were collected from an additional 131 non-randomly selected sites during 2001 as part of the Stream Waders volunteer monitoring program coordinated by DNR. This broad sampling density provides the opportunity for conducting overall watershed assessments. Despite this major monitoring effort, however, only about 1.5 percent of the total miles of streams in these watersheds were sampled by MBSS, with an additional 1.6 percent sampled by Stream Waders volunteers. The presence of minimally-degraded conditions, rare or unique resources, or severe degradation in any unsampled stream reaches cannot be ruled out. A more comprehensive survey of the streams in the watershed would be necessary to provide a complete inventory of resources and conditions. However, results of the MBSS and Stream Waders sampling efforts offer useful insights into the health of non-tidal streams in these six watersheds.

MBSS (Kazyak 2000) and Stream Waders (MDNR 2001) monitoring and assessment methods are described below:

### *Fish*

Fish assemblage data were collected using double-pass electrofishing with direct current backpack units. Each 75 m long site was blocked at each end using 0.25 in. mesh block nets and all available habitats were thoroughly sampled. For each pass, all captured fish were identified to species, counted, and released. Fishes were collected during summer (June - September) to avoid the effects of spring and fall spawning movements on fish assemblages and to maximize electrofishing catch efficiencies. Fish data were analyzed in terms of species richness, composition, relative abundance, and general pollution tolerance. A Fish Index of Biotic Integrity (FIBI) was also calculated (Roth et al. 1998; Roth et al. 1999). Probable stressors to the biota (fishes) at each site were diagnosed based on relationships between stressor variables and fish species presence and absence previously documented by the MBSS (Stranko et al. 2001).

### *Benthic Macroinvertebrates*

Benthic macroinvertebrates were collected by Stream Waders volunteers and MBSS biologists using D-frame sampling nets during spring (March-April). A 100 organism sub-sample of the benthos collected at each site was processed and identified by DNR staff for both programs. MBSS samples were identified to genus taxonomic level and Stream Waders samples were identified to family taxonomic level. These data were used to calculate a genus level and family-level benthic macroinvertebrate index of biotic integrity (BIBI) respectively for each site.

### *Rare, Threatened, and Endangered Taxa*

Any fish species identified by DNR's Natural Heritage Division as rare, threatened, or endangered based on the official State Threatened and Endangered Species List as part of the State of Maryland Threatened and Endangered Species regulations (COMAR 08.03.08) was noted.

### *Water Quality*

MBSS water chemistry sampling occurred during the spring of each sampling year (March - April). Water samples were analyzed for a suite of parameters which included closed pH, specific conductance, acid neutralizing capacity, dissolved organic carbon, sulfate, and nitrate.

Additional sampling of water quality occurred during the summer of each sampling year when *in situ* measurements were made concurrent with fish sampling. Prior to 2000, parameters measured included dissolved oxygen (DO), pH, conductivity, and temperature. During 2000, turbidity was added to the suite of summer sampling measurements. All measurements were taken with a HydrolabJ multiprobe water quality meter, except for turbidity which was measured with a LaMotteJ turbidity meter. Both instruments were calibrated before sampling according to MBSS QA/QC guidelines (Kazyak 2000).

### *Water Temperature*

Temperature loggers were placed at all MBSS sites during 2001. The loggers recorded water temperature every 15 minutes from 1 June through 1 September. Maximum temperatures over this period were reported for each site sampled during 2001, unless the temperature logger was lost or malfunctioned. Prior to 2001, temperature was measured only once during summer base-flow. The one-time temperature measurements are reported for sites sampled prior to 2000. Maryland freshwater streams are designated for different levels of protection from thermal impacts depending on the classification of the stream by the Maryland Department of the Environment. All

streams in the watersheds discussed in this report are designated as Use Class I, which means that the temperature should not exceed 32 ° C (COMAR 26.08.02).

### *Physical Habitat*

Physical habitat assessments were conducted to evaluate habitat effects on biota. MBSS habitat assessment procedures were derived from two methods: EPA's Rapid Bioassessment Protocols (Plafkin et al. 1989), as modified by Barbour and Stribling (1991), and Ohio EPA's Qualitative Habitat Evaluation Index (Ohio EPA 1987). Several parameters (instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, embeddedness, and shading) were scored based on visual observations. Bank stability was scored based on visual observations at sites sampled prior to 2000 and measurements of the amount and severity of erosion replaced the visual assessment at sites sampled after 1999.

### *Landscape*

The landscape within a watershed can have a profound influence on the physical habitat, chemistry, and biology of its streams. Some potentially important landscape scale factors including watershed area, physiography, geology, and soil type were described for each watershed. These factors are important in interpreting many biological, physical, and chemical findings, other than those related to human influences on streams. An additional landscape variable (land use) is also provided and can be used to investigate influences of human activities on stream ecological resources.

### *Land Use*

Arc View software was used to generate site-specific land use and impervious surface information for the catchment (land area draining to a stream from upstream) of each MBSS site using U.S. EPA Multi-Resolution Land Characteristic Consortium (MRLC) data. These land use data are based on Landsat<sup>TM</sup> data acquired between 1986-1993 and, as a result, ***do not reflect land use changes that have occurred since 1993.***

### *Quality Control/ Quality Assurance*

Quality control and quality assurance procedures for this project followed the MBSS methods. These procedures have been accepted by the U.S. Environmental Protection Agency and meet all requirements as outlined in "The Guidelines and Specifications for Preparing Project Plans", EPA QAMS 005/80.

### *Protection and Restoration Priorities*

For the purpose of this report, all of the land area draining to a site on a stream is defined as the site catchment. The physical, chemical, and biological conditions of a stream site depend largely on the conditions (land use and land cover) of the site catchment. Anthropogenic influences on land such as urbanization, agriculture, mining, and logging dramatically alter the ecological conditions of a stream site. All land in Maryland has been (either historically or recently) anthropogenically altered to some degree. Consequently, all streams in Maryland have also been anthropogenically altered to some degree. However, streams have been altered to lesser or greater degrees depending on the type and extent of land use alterations that have occurred in their catchments. Although the effects of historic alterations can be perpetual, in many cases, recent alterations probably affect streams more than historic alterations. The inherent ability of a stream to withstand the influence of anthropogenic alterations to the landscape is also important. Streams that presently exhibit conditions indicative of relatively minimal anthropogenic alterations are termed minimally-degraded in this report. Minimally-degraded streams often have Good IBI scores (scores greater

than 4.0 on a scale of 1.0-5.0 with 5.0 being the best possible score). Moderately-degraded streams typically have Fair IBI scores (3.0-3.9) and degraded and severely-degraded streams typically score in the Poor (2.0-2.9) or Very Poor (1.0-1.9) range respectively.

### Protection

A three tiered approach was used to prioritize land area for protection within each of the three watersheds covered by this report. IBI scores and the presence of rare or endangered species at MBSS sites were the basis for prioritizing an area for protection. Due to the influence of land use and land cover alterations on stream quality, catchments of MBSS sites with Good IBI scores (minimally-degraded conditions) were given top priority for protection. The second tier priority for protection included catchments of MBSS sites with Fair IBI scores (moderate degradation). The third, lowest, tier priority for protection includes sites that are degraded or severely degraded (Poor IBI scores).

### Restoration

A similar three-tiered approach was used to prioritize stream reaches for restoration within each watershed. The top priority for restoration was assigned to stream reaches in catchments that have been prioritized for protection. Since all streams in Maryland have been anthropogenically altered to some degree, stream reaches in catchments that have been prioritized for protection can also benefit from restoration. In many cases, the minimally degraded status of a site can only be maintained by improving stream conditions through restoration initiatives in its catchment. Conditions may actually improve in many minimally-degraded streams as a result of restoration initiatives in their catchments. There is also a greater potential for restoration success in minimally degraded catchments compared to severely degraded catchments because severely degraded catchments often suffer from the influence of a greater number of stressors. In addition, fewer reaches should need to be restored in minimally-degraded catchments. The second tier priority for restoration included stream reaches in catchments of MBSS sites with moderate degradation (Fair IBI scores). Finally, unless the impairment presents a human health hazard, it is recommended that restoration work on the third tier (severely-degraded sites with Poor IBI scores) be deferred until stream segments in higher priority catchments are restored.

Many stream reaches in priority protection catchments also in need of restoration have already been identified by the presence of an MBSS or Stream Waders sampling site. Poor IBI scores as well as data on severe or extensive bank erosion or insufficient vegetated riparian buffers and poor physical habitat ratings are available at MBSS sites and can be used to target stream reaches in need of restoration. Poor IBI scores at Stream Waders sites can also be used to find stream reaches within priority protection catchments that may also be in need of restoration. Good IBI scores at an MBSS or Stream Waders site in a priority protection catchment indicates that restoration may not be necessary in that particular stream segment containing the sampled site with the Good score is located. Neither the MBSS nor the Stream Waders program has sampled every reach of every stream in all priority protection catchments. Thorough surveys of habitat and water quality in all reaches of priority catchments are needed to find additional stream reaches where restoration may be necessary.

### *Potential Point Sources of Pollution*

Potential point sources of pollution to streams in each watershed from point sources were identified based on data from the National Pollutant Discharge Elimination System (NPDES) Program as administered by the U.S. Environmental Protection Agency (USEPA). The NPDES Program gives permits to facilities to discharge a specified amount of a pollutant into a receiving

water under certain conditions. Permits are given to two types of facilities: municipal and industrial. Municipal facilities are point where publicly-owned treatment works that receive sewage from both residential and commercial sources. Processes at these sites often produce wastewater and sludge. Industrial facilities discharge wastewater from industrial processes. Pollutants that are discharged vary widely and depend primarily on the type of industry.

#### *Good Quality or Degraded Variables*

Select water quality, physical habitat, land use, and biological variables sampled at each MBSS site were tabulated for each watershed. Cells on the tables with values indicating the presence of severe degradation were highlighted in gray. Cells with values indicating good quality (minimally degraded), rare, or unique stream resources were outlined in bold. Appendix A shows thresholds for classifying values as good quality or severely degraded.

#### *Probable Stressors to Biota*

In addition to the identification of variables, probable stressors to fish species at MBSS sites were diagnosed based on relationships previously documented by the MBSS. This method compares a list of the fish species expected to occur at an MBSS site with the species actually collected.

Specific variables with values that were outside of the tolerance range for the expected but absent species at a site were listed as probable stressors to those species at that site. Several physical, chemical and land use variables were identified as probable stressors to fishes using this approach.

All possible physical and chemical conditions could not be measured at MBSS sites and many that were measured were only measured one time and may not reflect the most severe conditions for biota. Therefore, the identification of land-use stressors is directly related to sensitivity of fishes to physical and chemical conditions that are likely to be more severe than reflected by other variables as a result of the conversion of land to impervious parking lots and roads or agricultural crops and pastures. Although sampling by the MBSS includes a large number of probable stream stressors, many variables not measured by the MBSS may be influencing fishes and were not detected. Discrete, one-time sampling by the MBSS may also miss important measurements that may be acting as stressors to stream biota.

## **Results/Discussion**

Results are presented by watershed. Maps depicting areas prioritized for restoration and protection are presented first (Figures 7-12). Possible point sources of pollution based on facilities with NPDES permits are shown on watershed maps (Figures 13-18). Tables that list select variables sampled at each site with values indicative of degradation (shaded gray) and values indicative of good quality (outlined in bold; Tables 1-6) follow the maps. Specific locations of MBSS and Stream Waders sites with site labels are shown on maps of each watershed in Appendix B.

### Back River

#### *Landscape*

The Back River watershed is located in Baltimore City and Baltimore County, Maryland, and encompasses 34,882 land acres. It lies within the Coastal Plain physiographic province. It's geology consists of unconsolidated mud, clay, quartz, silt, sand, and gravel, along with weathered residuum from which iron and carbonate have been removed. Soils in the watershed primarily consist of silt with varying proportions of sand, gravel, and clay. The dominant land use in the watershed is urban (77%), followed by forest (17%), agriculture (3%), barren (1%), and wetlands (1%).

### *Protection and Restoration Priorities*

MBSS sampled 22 sites and stream waders sampled 24 sites in the Back River watershed. All of the sampling sites in this watershed were degraded (received Poor scores) according to the fish or benthic macroinvertebrate IBIs. Since no streams were considered minimally degraded (received Good scores), no catchments in the Back River watershed were prioritized for protection and restoration. Since stream degradation appears to be widespread, extensive restoration efforts would be necessary to improve the ecological condition of this watershed (Figure 7).

### *Potential Point Sources of Pollution*

A large number of both municipal and industrial NPDES permits have been issued to facilities in the Back River watershed (Figure 13).

### *Good Quality or Degraded Variables*

All of the BIBI and 18 (82%) of the FIBI scores were in the Poor range in the watershed indicating that human influences to biota are widespread. The relatively large amount of urbanization, low dissolved oxygen, and poor physical habitat in most of the streams in this watershed were also indicative of degradation (Table 1). Despite extensive urbanization, temperature logger data collected during 2002 indicated that water temperatures only exceeded the water quality criteria maximum temperature in two streams, Herring Run and Stemmer's Run (Use Class I; 32 °C). This indicates that the biota in these two streams have probably experienced severe thermal stress.

### *Probable Stressors to Biota*

The most prevalent stressors to fish based on species absence where they were expected to occur in the Back River watershed were urbanization, poor physical habitat, and low dissolved oxygen. All of these stressors are indicative of a highly urbanized area like the Back River watershed.

### *Summary*

Most of the streams in the Back River watershed appear to be severely degraded due to extensive urbanization. Extensive restoration efforts would be necessary in this watershed to provide even marginal improvements to conditions. The greatest benefits to ecological resources are likely to be realized if restoration and protection funds were focused first in watersheds with better quality, rare, or unique conditions. Human health issues that may be resulting from urbanization effects on water quality may be a more important initial focus for this watershed compared to ecological restoration.

## Jones Falls

### *Landscape*

The Jones Falls watershed is located in the Piedmont physiographic province in Baltimore County, Maryland and encompasses 37,132 acres. The geology and soils of the Jones Falls watershed are similar to the Back River watershed. The primary geologic strata in the area consist of unconsolidated mud, clay, quartz, silt, sand, and gravel, along with weathered residuum from which iron and carbonate have been removed. Soils primarily consist of silt with varying proportions of

sand, gravel, and clay. The dominant land use in the watershed is urban (71%), followed by forest (19%), and agriculture (10%).

#### *Protection and Restoration Priorities*

MBSS sampled 27 and Stream Waders sampled 23 sites in the Jones Falls watershed. Four sites received Good scores for either the fish or benthic macroinvertebrate IBI. The catchments of these sites were given top priority for restoration and protection (Figure 8). These four sites were located on two streams including the North Branch of Jones Falls and Dipping Pond Run.

#### *Potential Point Sources of Pollution*

One Municipal and eight Industrial NPDES permits have been issued in the Jones Falls watershed (Figure 14).

#### *Good Quality or Degraded Variables*

Urban land use, impervious surface, and instream habitat were indicative of degraded streams at several sites (Table 2). Sixteen sites (59%) had Poor scores for the fish or benthic macroinvertebrate IBIs. Physical habitat was extremely poor at two sites on Stony Run (all scores were six or less on a scale of 0 to 20). Temperature logger data collected during 2002 indicated that water temperatures exceeded the water quality Use Class I criteria maximum temperature (32 °C ) at three streams including one of three sites on Jones Falls, a tributary to the North Branch, and Stony Run.

#### *Probable Stressors to Biota*

The most prevalent stressors to fish based on species absence where they were expected to occur in the Jones Falls watershed were acidity, thermal stress, poor physical habitat, and urbanization. These stressors are indicative of a highly urbanized area like the Jones Falls watershed.

#### *Summary*

Urbanization appears to have had an impact on the biological and physical conditions in portions of the Jones Falls watershed nearest and within Baltimore City. Focusing on the northwestern portion of the watershed is likely to provide the greatest ecological benefits.

### Breton Bay

#### *Landscape*

The Breton Bay watershed is located in Saint Mary's County, Maryland, and encompasses 35,275 acres. It lies entirely in the Coastal Plain physiographic province. The geologic strata in the area are dominated by unconsolidated mud and clay with mixtures of quartz, silt, sand, weathered residuum, organic rich deposits, and iron rich greensand. These rock types also tend to provide relatively little acid-neutralizing capacity and are highly porous (McCartan et. al. 1998). Sand is the dominant soil type. Silt, clay, and gravel are also abundant. The dominant land use in the watershed is forest (61%), followed by agriculture (26%), urban (12%), and wetlands (1%).

#### *Protection and Restoration Priorities*

MBSS sampled 7 sites and Stream Waders sampled 40 sites in the Breton Bay watershed. Three sites on Moll Dyer's Run, MacIntosh Run, and Burnt Mill Creek had Good scores for the fish or benthic macroinvertebrate IBI. The streams in the catchments draining to these sites, should receive top priority for protection and restoration (Figure 9). The site on Burnt Mill Creek had both fish and benthic IBI scores in the Good range and may be the best candidate for protection and

restoration. The extensive distribution of a large number of samples taken by Stream Waders illustrates the usefulness of this volunteer effort in prioritizing management activities in a watershed. Many stream waders sites located on streams that were not sampled by MBSS received low IBI scores. These low scores indicate that restoration may be necessary in these streams. The Stream Waders sites, therefore, may provide a basis for planning additional monitoring needs to further investigate the restoration and protection potential in the Breton Bay watershed.

#### *Potential Point Sources of Pollution*

One Industrial and one Municipal NPDES permit were issued in the southernmost portion of the Breton Bay watershed. Neither of them is located in catchments that are recommended as top priority for protection and restoration (Figure 15 ).

#### *Good Quality or Degraded Variables*

Few impacts were evident in streams in the Breton Bay watershed. Sources of stress to the streams from urbanization and agriculture seem to be limited due to a great deal of forested land which remains throughout the watershed. Three (43%) MBSS sites had Poor scores for the fish or benthic macroinvertebrate IBI. Dissolved oxygen was low at one site, physical habitat scores were moderately low at one site and bank erosion was extensive at another. In addition, five of the seven sites sampled by MBSS had moderately low pH (<6.5).

#### *Probable Stressors to Biota*

No specific stressors to fishes were identified in the Breton Bay watershed.

#### *Summary*

According to MBSS sampling, most of the streams in the Breton Bay watershed appear to be in good ecological condition. Stream Waders sites may provide insight into areas that are in need of restoration within priority protection and restoration watersheds.

### South River

#### *Landscape*

The South River watershed is located in Anne Arundel County, Maryland, and encompasses 36,521 acres. It is located in the Coastal Plain physiographic province. The primary geologic strata in the area consist of unconsolidated mud, clay, quartz, silt, sand, and weathered residuum. Greensand and iron ore are also present. Sand is the dominant soil type in the watershed. Silt, clay, and gravel are also abundant. The dominant land use in the watershed is forest (51%), followed by urban (29%), and agriculture (20%).

#### *Protection and Restoration Priorities*

MBSS sampled 10 sites and Stream Waders sampled 43 sites in the South River watershed. Fish IBI scores were Good at two sites on Tarnans Branch. The catchments draining to the two sites on this stream should receive top priority for protection and restoration (Figure 10).

#### *Potential Point Sources of Pollution*

Only three (two Industrial and one Municipal) NPDES permits have been issued in the South River watershed. None of these are in portions of the watershed that are recommended priorities for restoration and protection (Figure 16).

### *Good Quality or Degraded Variables*

Urbanization and agriculture land use do not appear to dominate any of the catchments draining to any of the MBSS sampling sites. However, nine of ten sites scored in the Poor range for the benthic macroinvertebrate IBI, indicating that degradation is relatively widespread in the South River watershed. Poor physical habitat quality in many streams appears to be the most common degradation. Dissolved oxygen was also low (<5.0 mg/l) at three sites (Table 4). Many MBSS and Stream Waders sites with severe degradation were located in the catchments of streams identified as in need of protection and could be a basis for beginning to locate areas within priority protection watersheds that require restoration.

### *Possible Stressors to Biota*

Acidity was the only probable stressor to fishes identified, based on expected species absences, in this watershed.

### *Summary*

Degradation appears to be relatively widespread in the South River watershed. Poor physical habitat and acidity are the most likely sources of degradation. The Tarnan's branch portion of the watershed appears to be the least degraded area. The many Stream Waders sites in this watershed provide valuable information to target areas that may be in need of management action.

## Bird River

### *Landscape*

The Bird River watershed is located in Baltimore County, Maryland, and encompasses 16,595 acres. It lies within the Coastal Plain physiographic province. The primary geologic strata in the area consist of iron rich green sand and bog iron ore but also consist of unconsolidated clay, silt, and mud. These rock types tend to provide relatively little acid-neutralizing capacity (McCartan et. al. 1998). Soils in the watershed primarily consist of sand, silt, and clay. The dominant land use in the watershed is urban (43%), followed by forest (38%), agriculture (16%), wetland (2%), and barren (1%).

### *Protection and Restoration Priorities*

A total of 4 MBSS and two Stream Wader sites were sampled in this small watershed. Two of the sites were degraded (received Poor scores) according to the fish or benthic macroinvertebrate IBIs and three sites received fair scores for the fish IBI. Since no streams were considered minimally degraded (received Good scores), no catchments in the Bird River watershed were given top priority for protection and restoration. The two sites on White Marsh Run and one site on Honeygo Run that were scored Fair for the fish IBI, received second tier priority for protection. White Marsh Run has probably benefited from the extensive habitat improvement work that has been conducted within the portions that are closest to large parking lots and other impervious surfaces (Figure 11).

### *Potential Point Sources of Pollution*

Cargill Incorporated is the only facility with an NPDES permit in the Bird River watershed (Figure 17).

### *Good Quality or Degraded Variables*

Much of the Bird River watershed is under a great deal of stress from impervious run-off and urban development. However, since habitat scores were mostly in the sub-optimal range, the habitat improvement work that has been conducted in White Marsh Run may be improving habitat within the watershed.

#### *Probable Stressors to Biota*

Urbanization and erosion were identified as stressors to fishes at all sites in the Bird River watershed. Extensive habitat improvement efforts have been underway in White Marsh Run and are likely to improve ecological conditions. Extensive efforts may be needed in other parts of the watershed if overall conditions of the watershed are expected to improve.

#### *Summary*

Although top priority for restoration and protection in this report were given to Good IBI scores, portions of White Marsh Run appear to have benefited from habitat improvement work that has been conducted. A great deal more work is still necessary to improve the overall ecological condition of White Marsh Run and other streams in the watershed.

### Lower Pocomoke River

#### *Landscape*

The Lower Pocomoke River watershed is located in Somerset and Worcester Counties, Maryland, and encompasses 98,891 acres within the Coastal Plain physiographic province. Primary geologic strata in the area consist of unconsolidated quartz, silt, sand and gravel along with weathered residuum. These rock types tend to provide little acid-neutralizing capacity and are very porous (McCartan et. al. 1998). Soils in the watershed consist primarily of silt with varying proportions of sand and clay. Dominant land use forest (58%), followed by agriculture (36%), urban (4%), and wetlands (2%).

#### *Protection and Restoration Priorities*

MBSS sampled 12 sites and Stream Waders sampled 26 sites in the Lower Pocomoke River watershed. Only one site on Jones Ditch had a Good Fish IBI score and no sites had a Good benthic macroinvertebrate IBI score. Nearly all other IBI scores (84% for MBSS and 92% for Stream Waders) were Poor, indicating that extensive restoration efforts may be necessary in this watershed. Two rare species of fishes were collected in the Lower Pocomoke River watershed. Mud sunfish were collected at Puncheon Landing Branch and swamp darters were collected at Poorhouse Branch. The biodiversity of this watershed and Maryland in general would benefit from the protection of the catchments draining to these streams. In addition, restoration within these catchments would help insure the protection of these fishes and could improve their chances of long term survival in this system (Figure 12).

#### *Potential Point Sources of Pollution*

A total of nine NPDES permits have been issued within the Lower Pocomoke River watershed. None of these permits have been issued to facilities that are located within catchments where rare fishes reside or good IBI scores were measured (Figure 18).

#### *Good Quality or Degraded Variables*

The majority of MBSS sites scored in the Poor range for the fish and macroinvertebrate IBI in the Lower Pocomoke watershed indicating that human influences to biota are widespread. However,

the presence of state rare fish species at sites with Good fish IBI scores indicates that good quality conditions exist in the watershed. Poor physical habitat and high nitrate values were measured at a large majority of sites. This is most likely due to the widespread agricultural land use and channelization of streams in this area.

#### *Probable Stressors to Biota*

Acidity and Poor physical habitat and thermal stress were identified as possible stressors to fishes in the Lower Pocomoke River watershed (Table 12). Additional stress is likely to come from widespread channelization. However, the cause of stress to biota that may result from widespread channelization of streams may be difficult to measure and diagnose.

#### *Summary*

Although small portions of the Lower Pocomoke River watershed contain rare species or Good IBI scores, these portions of the watershed are important to protect. The Lower Pocomoke River watershed has state listed rare species of fish making it a unique watershed in Maryland. In addition, the majority of streams appear to be degraded by anthropogenic sources. Many streams have been channelized, which may explain some of the degradation observed in the watershed. Restoring sinuosity to channelized streams is likely to be extremely expensive and time consuming. However, maintaining vegetated buffers and limiting the amount of nutrient run-off entering streams is likely to improve conditions in even the least degraded streams.

### **Conclusions**

This report is meant to convey information that could be used to provide the greatest possible benefit to stream ecological resources in the Back River, Jones Falls, Breton Bay, South River, Bird River, Lower Pocomoke River watersheds, based on the best monitoring data presently available. This report pertains exclusively to ecological resources and should be considered as part of a comprehensive watershed restoration and protection plan that also considers benefits to social and economic resources.

Specific areas in need of protection or restoration within the Back River, Jones Falls, Breton Bay, South River, Bird River, and Lower Pocomoke River watersheds are identified in this report based on surveys of the watersheds by the Maryland Biological Stream Survey (MBSS). However, more comprehensive surveys of stream conditions with higher sample site densities and directed stream walks using methods like DNR's Stream Corridor Assessment survey (Yetman 2000), in the upstream catchments of minimally-degraded streams would provide additional information necessary to plan detailed restoration work that would ensure even greater benefits to streams in these watersheds. Volunteer sampling results from DNR's Stream Waders program are also presented in this assessment to help identify specific sites within areas prioritized for protection that are in need of restoration. With the abundance of biological, physical habitat, and chemical data available from the MBSS and Stream Waders program in these watersheds, supplemental surveys of stream bank erosion, width of vegetated riparian buffers, and general instream habitat quality could be used to identify areas where buffer planting projects, stream bank stabilization, storm water controls, or other restoration improvements could be implemented. In most cases, we recommend that a long-term, lower cost approach to stream habitat improvements such as riparian buffer plantings be evaluated first before expensive channel modifications are considered. Ecological monitoring that includes the collection of biological, physical habitat, and chemical conditions throughout these priority watersheds should continue on a regular basis to document improvements in ecological conditions over time as restoration and protection strategies are implemented.

## References

- Barbour, M.T. and Stribling, J.B. 1991. *Biological Criteria: Research and Regulation*. U.S. Environmental Protection Agency, Washington, D.C.
- Kazyak, P.F. 2000. *Maryland Biological Stream Survey Sampling Manual*. Prepared by the Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources. Annapolis, MD.
- McCartan, L., J.D. Peper, L.J. Bachman, and J.W. Horton. 1998. Application of geologic map information to water quality issues in the southern part of the Chesapeake Bay watershed, Maryland and Virginia, eastern United States. *Journal of Geochemical Exploration* 00(1998) 1-22.
- MDNR. 2001. Maryland Stream Waders volunteer stream monitoring manual. Maryland Department of Natural Resources. Monitoring and Non-tidal Assessment Division, Annapolis, Maryland.
- Ohio EPA. 1987. *Biological Criteria for the Protection of Aquatic Life*. Ohio Environmental Protection Agency, Columbus, Ohio.
- Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., Hughes, R.M. 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers*. U.S. Environmental Protection Agency, Washington, D.C.
- Roth N, M. and eight coauthors. 1998. Maryland biological stream survey: development of a fish index of biotic integrity. *Environmental Monitoring and Assessment* 51: 89-106.
- Roth, N. E., and eight coauthors. 1999. State of the Streams: 1995-1997 Maryland Biological Stream Survey Results. EA-99-6. Prepared for the Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources, Annapolis, MD CBWP-MANTA.
- Stranko, S.A., Hurd, M.K., and R.J. Klauda. 2001. ms. The development of a predictive model that uses the presence and absence of fish species to assess biological integrity and diagnose ecological stressors in streams. In review by the *Ecological Indicators Journal*.
- Yetman, K.T., 2000. Stream Corridor Assessment Survey - Survey Protocols. Watershed Restoration Division, Maryland Department of Natural Resources, Annapolis, MD.



Table 1. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Back River watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>Back River</b>										
<b>Parameter</b>	<b>211-96</b>	<b>223-96</b>	<b>128-96</b>	<b>215-96</b>	<b>216-95</b>	<b>217-96</b>	<b>224-95</b>	<b>202-96</b>	<b>219-95</b>	<b>205-95</b>
Fish IBI Score	1.7	3.3	1.2	2.6	2.5	1.7	3.0	1.2	2.6	1.9
Macroinvertebrate IBI Score	1.0	1.0	1.3	1.0	1.3	1.0	1.9	1.0	1.3	1.2
NO3	0.68	1.46	0.47	1.45	1.21	0.80	1.07	1.68	1.52	2.64
D.O. (mg/L)	8.1	7.5	7.9	8.9	4.4	7.8	9.0	7.6	7.6	8.6
pH (units)	7.21	7.30	7.07	7.36	7.36	6.96	7.42	7.50	8.04	8.36
Sulfate	13.35	19.97	11.13	28.48	40.67	7.38	38.54	19.38	18.16	27.16
Temperature (*= maximum summer temperature from temperature loggers)	22.9	23.4	21.6	23.3	25.8	22.2	28.9	23.7	24.7	26.4
Turbidity										
Instream Habitat Score	9	8	15	16	10	17	12	15	15	14
Epifaunal Substrate Score	9	12	10	14	8	18	4	14	15	13
Velocity/Depth Diversity	10	12	8	13	8	13	7	8	18	8
Pool Quality Score	16	11	18	16	15	14	16	6	13	11
Eroded Bank Area (m <sup>2</sup> )										
Erosion Severity Score										
Bank Stability	11	5	8	6	10	10	8	16	6	16
Embeddedness	50	30	80	70	40	15	60	45	5	5
Buffer Width	0	0	0	0	0	0	0	0	0	0
Agricultural Land Use (%)	17.73	11.11	7.73	15.46	5.74	3.60	5.73	8.98	9.72	9.99
Urban Land Use (%)	60.41	76.36	73.88	62.02	85.23	88.57	85.28	77.28	76.49	79.74
Impervious Land Cover (%)	18.04	26.80	21.50	18.91	27.28	28.07	27.30	25.25	25.05	25.88

Table 1. Continued										
<b>Back River</b>										
<b>Parameter</b>	<b>228-96</b>	<b>107-96</b>	<b>101-02</b>	<b>105-02</b>	<b>108-02</b>	<b>110-02</b>	<b>111-02</b>	<b>112-02</b>	<b>113-02</b>	<b>203-02</b>
Fish IBI Score	1.2	1.0		2.1	3.8	1.4	3.0	3.3	1.9	3.8
Macroinvertebrate IBI Score	1.0	1.4	1.7	2.3	1.9	1.7	1.9	1.6	2.1	1.9
NO3	1.35	2.42	1.73	1.37	1.47	1.51	0.69	1.00	1.35	0.77
D.O. (mg/L)	6.6	0.9	6.9	10.2	5.4	10.8	7.0	5.9	6.7	6.5
pH (units)	7.48	7.50	7.40	8.32	8.15	8.52	7.91	7.92	7.91	7.52
Sulfate	21.53	19.41	24.78	35.89	53.53	31.82	37.10	35.10	27.64	32.77
Temperature (*= maximum summer temperature from temperature loggers)	22.9	21.7	27.1*	24.2	29.1*	32.6*	27.7*	27.8*	19.4	26.3*
Turbidity			6	1	2	7	6	2	0	7
Instream Habitat Score	11	3	10	11	5	13	6	9	14	6
Epifaunal Substrate Score	16	2	13	11	3	15	6	10	15	4
Velocity/Depth Diversity	15	1	7	12	7	7	8	5	7	3
Pool Quality Score	13	12	7	13	11	7	7	9	7	8
Eroded Bank Area (m <sup>2</sup> )			40	110	10	20	100	160	70	70
Erosion Severity Score			2.0	2.5	0.5	2.0	2.0	2.0	2.0	1.0
Bank Stability	11	5								
Embeddedness	10	0	40	40	100	60	65	40	40	80
Buffer Width	0	0	20	2	0	10	4	50	50	10
Agricultural Land Use (%)	9.90	2.54	2.15	17.46	18.67	17.34	6.42	4.41	13.99	17.52
Urban Land Use (%)	80.02	86.86	89.05	63.91	73.93	63.63	77.32	86.95	64.86	59.55
Impervious Land Cover (%)	25.85	27.83	30.88	19.26	24.55	19.34	23.11	27.29	19.74	19.79

Table 1. Continued		
<b>Back River</b>		
<b>Parameter</b>	<b>302-02</b>	<b>306-02</b>
Fish IBI Score	1.9	1.7
Macroinvertebrate IBI Score	2.3	1.7
NO3	1.04	1.31
D.O. (mg/L)	8.3	2.2
pH (units)	7.90	8.12
Sulfate	26.79	25.38
Temperature (*= maximum summer temperature from temperature loggers)	30.3*	38.3*
Turbidity	2	0
Instream Habitat Score	10	10
Epifaunal Substrate Score	12	14
Velocity/Depth Diversity	14	6
Pool Quality Score	11	7
Eroded Bank Area (m <sup>2</sup> )	30	0
Erosion Severity Score	1.5	0.0
Bank Stability		
Embeddedness	30	55
Buffer Width	15	40
Agricultural Land Use (%)	10.53	8.13
Urban Land Use (%)	75.51	78.96
Impervious Land Cover (%)	24.30	25.65

Table 2. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Jones Falls watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>Jones Falls</b>										
<b>Parameter</b>	<b>303-96</b>	<b>319-95</b>	<b>106-96</b>	<b>315-96</b>	<b>322-95</b>	<b>123-95</b>	<b>109-95</b>	<b>214-96</b>	<b>321-95</b>	<b>120-96</b>
Fish IBI Score	2.6	2.6	1.0	3.0	2.6			1.0	3.2	1.0
Macroinvertebrate IBI Score	3.0	2.8	2.1	3.7	3.4	3.0	3.7	1.2	3.2	1.0
NO3	1.69	1.81	2.00	1.32	1.37	0.50	2.51	3.20	1.87	0.18
D.O. (mg/L)	9.7	8.6	8.7	8.3	8.2	7.0	8.7	8.2	10.2	8.5
pH (units)	7.87	8.01	7.43	7.60	7.65	7.26	6.77	7.99	8.11	7.45
Sulfate	10.08	10.59	33.24	7.36	4.77	3.35	2.09	78.58	12.98	22.80
Temperature (*= maximum summer temperature from temperature loggers)	17.7	19.2	19.0	18.5	17.1	20.2	15.9	23.0	22.6	21.6
Turbidity										
Instream Habitat Score	18	9	7	19	14	3	13	15	12	10
Epifaunal Substrate Score	16	17	11	18	17	2	13	12	10	11
Velocity/Depth Diversity	19	16	8	18	10	3	7	12	17	12
Pool Quality Score	17	12	7	17	11	3	8	12	16	11
Eroded Bank Area (m <sup>2</sup> )										
Erosion Severity Score										
Bank Stability	10	10	18	12	10	5	7	11	8	10
Embeddedness	30	10	80	20	15	100	25	65	50	35
Buffer Width	0	0	0	50	39	0	40	0	0	0
Agricultural Land Use (%)	31.33	31.61	4.13	33.24	36.51	48.39	23.68	19.26	30.66	4.74
Urban Land Use (%)	8.10	7.77	72.27	4.12	3.44	0.00	2.06	52.47	14.13	74.94
Impervious Land Cover (%)	2.14	2.09	21.16	1.06	0.88	0.00	0.62	15.46	4.09	27.18

Table 2. Continued										
<b>Jones Falls</b>										
<b>Parameter</b>	<b>101-02</b>	<b>102-02</b>	<b>105-02</b>	<b>107-02</b>	<b>109-02</b>	<b>109-S</b>	<b>110-02</b>	<b>204-02</b>		
Fish IBI Score	2.8	1.0	1.0		1.9		1.4	2.6		
Macroinvertebrate IBI Score	3.9	1.4	1.4	4.1	3.2	3.9	2.1	3.9		
NO3	2.10	4.15	1.64	0.60	1.47	3.17	2.03	2.05		
D.O. (mg/L)	9.4	0.7	17.9		9.3	7.8	8.2	9.3		
pH (units)	7.90	7.79	7.71	7.04	7.71	6.41	7.72	7.80		
Sulfate	5.16	30.86	33.54	4.94	17.07	1.25	35.03	5.06		
Temperature (*= maximum summer temperature from temperature loggers)	19.2	38.2*	38.1*	29.1*	30.2*	20.8*	20.4	33.4*		
Turbidity	0	7	2		0	2	0	33		
Instream Habitat Score	14	1	1		12	16	13	10		
Epifaunal Substrate Score	11	1	2		14	16	13	12		
Velocity/Depth Diversity	12	1	2		7	11	8	7		
Pool Quality Score	13	6	6		8	11	8	7		
Eroded Bank Area (m <sup>2</sup> )	20	130	0		260	60	110	50		
Erosion Severity Score	1.0	3.0	0.0		2.5	2.0	2.0	2.0		
Bank Stability										
Embeddedness	50	57	100		30	35	20	35		
Buffer Width	50	48	14	40	50	50	30	50		
Agricultural Land Use (%)	44.24	14.22	4.05	21.33	19.87	22.75	7.63	42.19		
Urban Land Use (%)	1.84	59.69	77.70	0.14	41.17	0.47	75.44	1.17		
Impervious Land Cover (%)	0.46	17.45	24.07	0.04	12.20	0.36	27.92	0.29		

Table 2. Continued					
<b>Jones Falls</b>					
<b>Parameter</b>	<b>213-02</b>	<b>303-02</b>	<b>312-02</b>	<b>315-02</b>	<b>322-00</b>
Fish IBI Score	2.6	3.0	3.4	3.4	2.8
Macroinvertebrate IBI Score	3.7	3.4	1.7	3.4	4.3
NO3	2.05	1.67	1.14	0.96	0.93
D.O. (mg/L)	8.8	7.2	7.4	8.7	9.7
pH (units)	7.83	8.05	7.94	8.05	7.53
Sulfate	6.48	12.73	15.97	5.60	6.75
Temperature (*= maximum summer temperature from temperature loggers)	20.8*	26.5*	35.3*	30.1*	22.7*
Turbidity	4	6	4	1	2
Instream Habitat Score	17	18	17	19	12
Epifaunal Substrate Score	18	16	14	19	17
Velocity/Depth Diversity	13	16	17	15	9
Pool Quality Score	13	16	16	19	10
Eroded Bank Area (m <sup>2</sup> )	60	190	0	50	100
Erosion Severity Score	2.0	2.0	0.0	1.5	2.0
Bank Stability					
Embeddedness	35	42	55	16	15
Buffer Width	50	50	0	50	50
Agricultural Land Use (%)	28.75	30.02	39.91	34.69	37.03
Urban Land Use (%)	11.07	15.42	18.90	3.91	37.03
Impervious Land Cover (%)	2.98	4.86	6.59	14.62	0.86

Table 3. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Breton Bay watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>Breton Bay</b>							
<b>Parameter</b>	<b>212-95</b>	<b>128-95</b>	<b>101-02</b>	<b>103-02</b>	<b>115-02</b>	<b>117-02</b>	<b>408-02</b>
Fish IBI Score	4.0	3.8					2.5
Macroinvertebrate IBI Score	4.4	3.9	4.1	1.6	2.7	3.0	4.7
NO3	0.45	0.22	0.07	0.05	0.00	0.09	0.20
D.O. (mg/L)	6.5	6.5	6.7				2.6
pH (units)	6.92	6.32	5.90	6.09	5.32	6.06	7.33
Sulfate	8.38	8.34	3.98	11.57	7.07	10.04	8.20
Temperature (*= maximum summer temperature from temperature loggers)	19.4	22.0	24.4*				21.1
Turbidity			5				18
Instream Habitat Score	17	8	14				14
Epifaunal Substrate Score	17	5	16				10
Velocity/Depth Diversity	15	8	7				10
Pool Quality Score	15	7	9				15
Eroded Bank Area (m <sup>2</sup> )			80				240
Erosion Severity Score			2.0				2.0
Bank Stability	11	4					
Embeddedness	10	60	30				39
Buffer Width	50	50	15	45	50	50	50
Agricultural Land Use (%)	34.80	23.03	5.60	17.55	12.99	16.06	20.96
Urban Land Use (%)	3.55	8.91	0.00	8.32	2.54	16.39	4.91
Impervious Land Cover (%)	0.99	2.27	0.00	2.31	1.34	4.54	1.49

Table 4. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the South River watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>South River</b>										
<b>Parameter</b>	<b>103-97</b>	<b>122-97</b>	<b>217-97</b>	<b>109-97</b>	<b>101-02</b>	<b>103-02</b>	<b>105-02</b>	<b>106-02</b>	<b>108-02</b>	<b>109-02</b>
Fish IBI Score	4.0				2.0				5.0	
Macroinvertebrate IBI Score	2.1	1.9	2.7	1.3	3.0	1.9	1.6	1.9	2.4	2.7
NO3	0.39	0.28	0.31	1.31	0.67	0.87	0.18	0.82	0.13	0.49
D.O. (mg/L)	7.5	7.6			8.8	6.8	7.2	3.5	4.9	4.5
pH (units)	6.60	5.65	5.14	7.05	6.43	5.79	5.47	5.79	6.10	6.02
Sulfate	18.06	16.92	17.49	23.87	3.16	27.95	13.65	4.83	12.45	24.87
Temperature (*= maximum summer temperature from temperature loggers)	24.4	19.2			25.2*	23.0*	17.0*	15.8	25.8*	26.1*
Turbidity					4	7	13	11	24	9
Instream Habitat Score	12	5			7	3	5	3	9	6
Epifaunal Substrate Score	11	3			11	3	5	3	8	9
Velocity/Depth Diversity	10	3			6	2	11	6	11	10
Pool Quality Score	12	3			7	2	11	6	12	14
Eroded Bank Area (m <sup>2</sup> )					40	60	20	140	20	140
Erosion Severity Score					1.0	2.0	1.0	2.0	1.0	3.0
Bank Stability	3	18								
Embeddedness	70	100			100	55	100	75	100	55
Buffer Width	21	50			50	0	50	35	50	50
Agricultural Land Use (%)	50.63	10.65	29.75	48.26	12.25	65.70	5.84	25.13	37.32	59.44
Urban Land Use (%)	6.50	0.00	2.35	17.43	5.18	13.59	26.62	14.81	6.74	5.57
Impervious Land Cover (%)	1.86	0.00	0.72	4.46	1.84	3.40	9.42	3.84	4.81	1.44

Table 5. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Bird River watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>Bird River</b>				
<b>Parameter</b>	<b>101-02</b>	<b>107-02</b>	<b>wmres</b>	<b>wmcon</b>
Fish IBI Score	2.3	3.2	3.00	3.5
Macroinvertebrate IBI Score	2.3	2.1		
NO3	0.34	0.97		
D.O. (mg/L)	6.4	7.5		
pH (units)	7.83	7.21		
Sulfate	31.36	22.66		
Temperature (*= maximum summer temperature from temperature loggers)	28.8*	25.7*		
Turbidity	4	4		
Instream Habitat Score	12	13	14	15
Epifaunal Substrate Score	13	13	8	8
Velocity/Depth Diversity	9	12	13	13
Pool Quality Score	9	14	16	14
Eroded Bank Area (m <sup>2</sup> )	90	150		
Erosion Severity Score	2.0	3.0		
Bank Stability				
Embeddedness	35	40	45	40
Buffer Width	48	50	0	50
Agricultural Land Use (%)	18.87	60.16		
Urban Land Use (%)	58.71	9.20		
Impervious Land Cover (%)	17.85	2.72		

Table 6. Select water quality, physical habitat, land use and biological parameters measured at MBSS sites in the Lower Pocomoke River watershed. Values indicating degradation are highlighted in gray. Values outlined in bold indicate good quality stream resources.

<b>Lower Pocomoke River</b>										
<b>Parameter</b>	<b>110-97</b>	<b>229-97</b>	<b>101-02</b>	<b>108-02</b>	<b>109-02</b>	<b>110-02</b>	<b>112-02</b>	<b>115-02</b>	<b>116-02</b>	<b>118-02</b>
Fish IBI Score	4.3		1.0		3.5	3.8		1.0	2.0	1.0
Macroinvertebrate IBI Score	1.9	2.1	1.9	1.6	2.4	2.4	1.9	1.6	1.6	1.6
NO3	1.46	1.07	0.05	0.39	0.41	11.04	0.37	1.34	0.54	1.32
D.O. (mg/L)	3.5		7.5	5.6	3.6	5.4		7.2	4.5	8.2
pH (units)	6.41	6.48	4.01	5.41	6.31	6.30	5.01	6.95	6.16	6.81
Sulfate	19.61	31.75	79.33	65.60	72.94	23.42	90.24	63.41	44.20	70.28
Temperature (*= maximum summer temperature from temperature loggers)	18.8		34.1*	38.2*	33.6*	34.0*	34.6*	34.1*	34.4*	34.1*
Turbidity			1	82	42	2		20	30	20
Instream Habitat Score	13		11	12	11	15		6	5	10
Epifaunal Substrate Score	11		12	6	4	14		6	5	12
Velocity/Depth Diversity	9		5	4	9	10		3	4	5
Pool Quality Score	15		9	6	11	14		4	8	9
Eroded Bank Area (m <sup>2</sup> )			0	0	0	60		0	10	60
Erosion Severity Score			0.0	0.0	0.0	1.0		0.0	0.5	1.0
Bank Stability	11									
Embeddedness	100		100	100	95	85		100	100	100
Buffer Width	35		32	0	0	50	0	0	25	0
Agricultural Land Use (%)	54.24	49.68	59.69	30.41	44.55	35.93	39.53	57.20	21.72	57.68
Urban Land Use (%)	0.03	0.40	0.03	0.00	0.00	0.03	0.61	0.00	0.04	0.00
Impervious Land Cover (%)	0.02	0.22	0.02	0.00	0.00	0.01	0.46	0.00	0.03	0.00

Table 6. Continued		
<b>Lower Pocomoke River</b>		
<b>Parameter</b>	<b>206-02</b>	<b>211-02</b>
Fish IBI Score	2.5	2.5
Macroinvertebrate IBI Score	1.9	1.9
NO3	0.00	0.00
D.O. (mg/L)	4.1	4.8
pH (units)	5.87	5.81
Sulfate	67.04	66.08
Temperature (*= maximum summer temperature from temperature loggers)	32.2*	32.2*
Turbidity	18	15
Instream Habitat Score	8	10
Epifaunal Substrate Score	8	8
Velocity/Depth Diversity	3	5
Pool Quality Score	7	10
Eroded Bank Area (m <sup>2</sup> )	0	0
Erosion Severity Score	0.0	0.0
Bank Stability		
Embeddedness	100	100
Buffer Width	50	50
Agricultural Land Use (%)	44.42	44.88
Urban Land Use (%)	0.47	0.48
Impervious Land Cover (%)	0.13	0.13

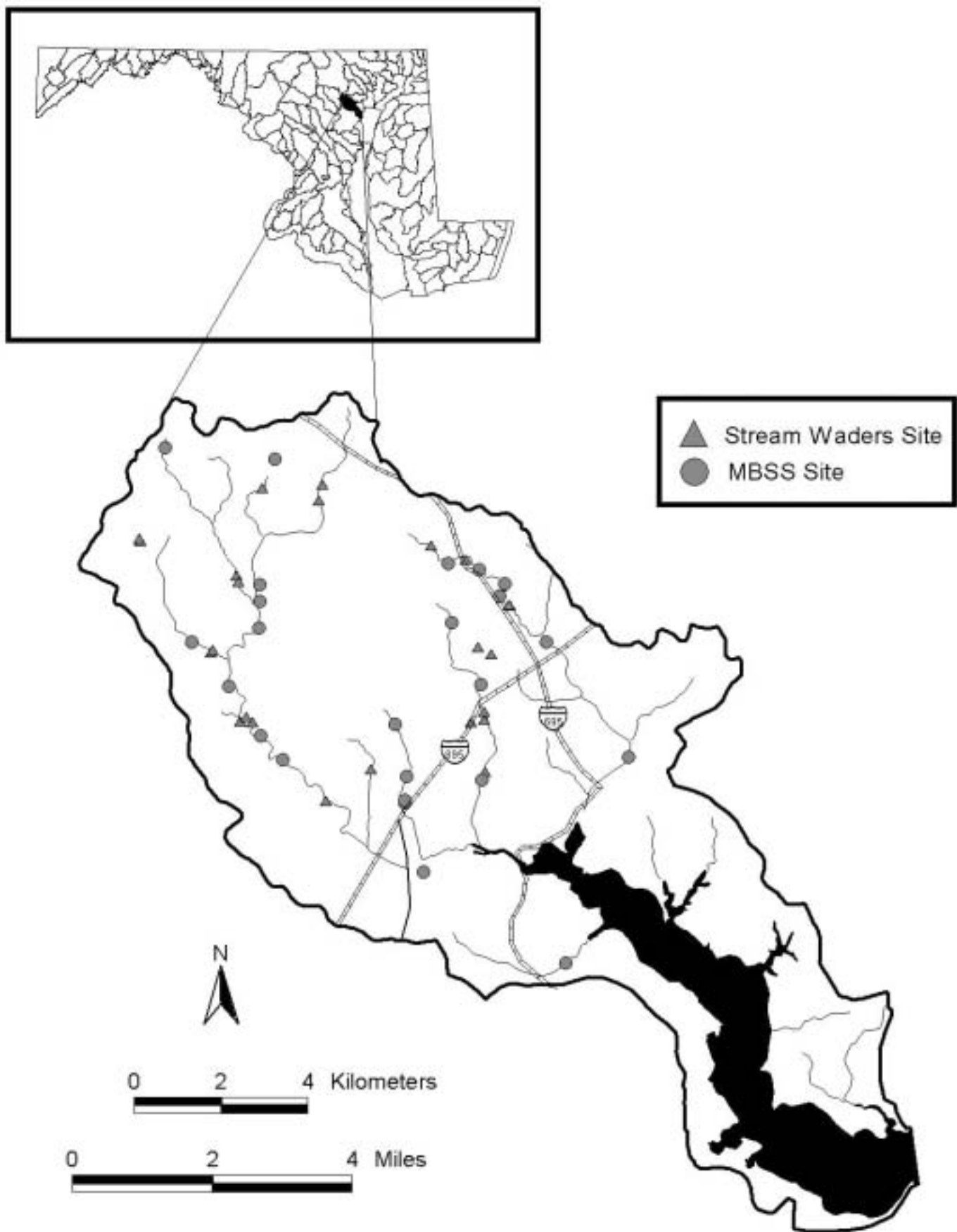


Figure 1. Sites sampled in Back River watershed from 1995 to 2002.

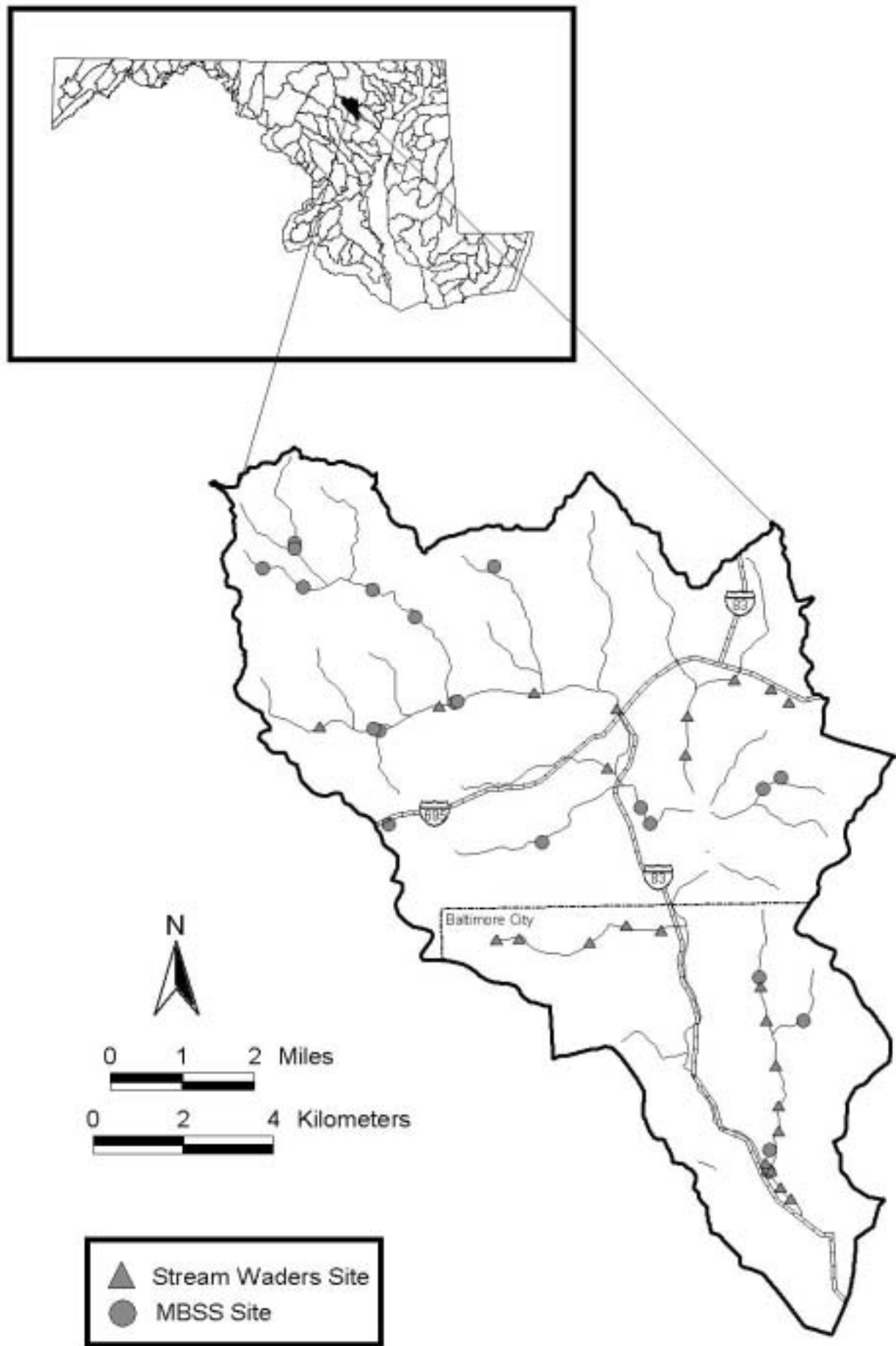


Figure 2. Sites sampled in Jones Falls watershed from 1995 - 2002.

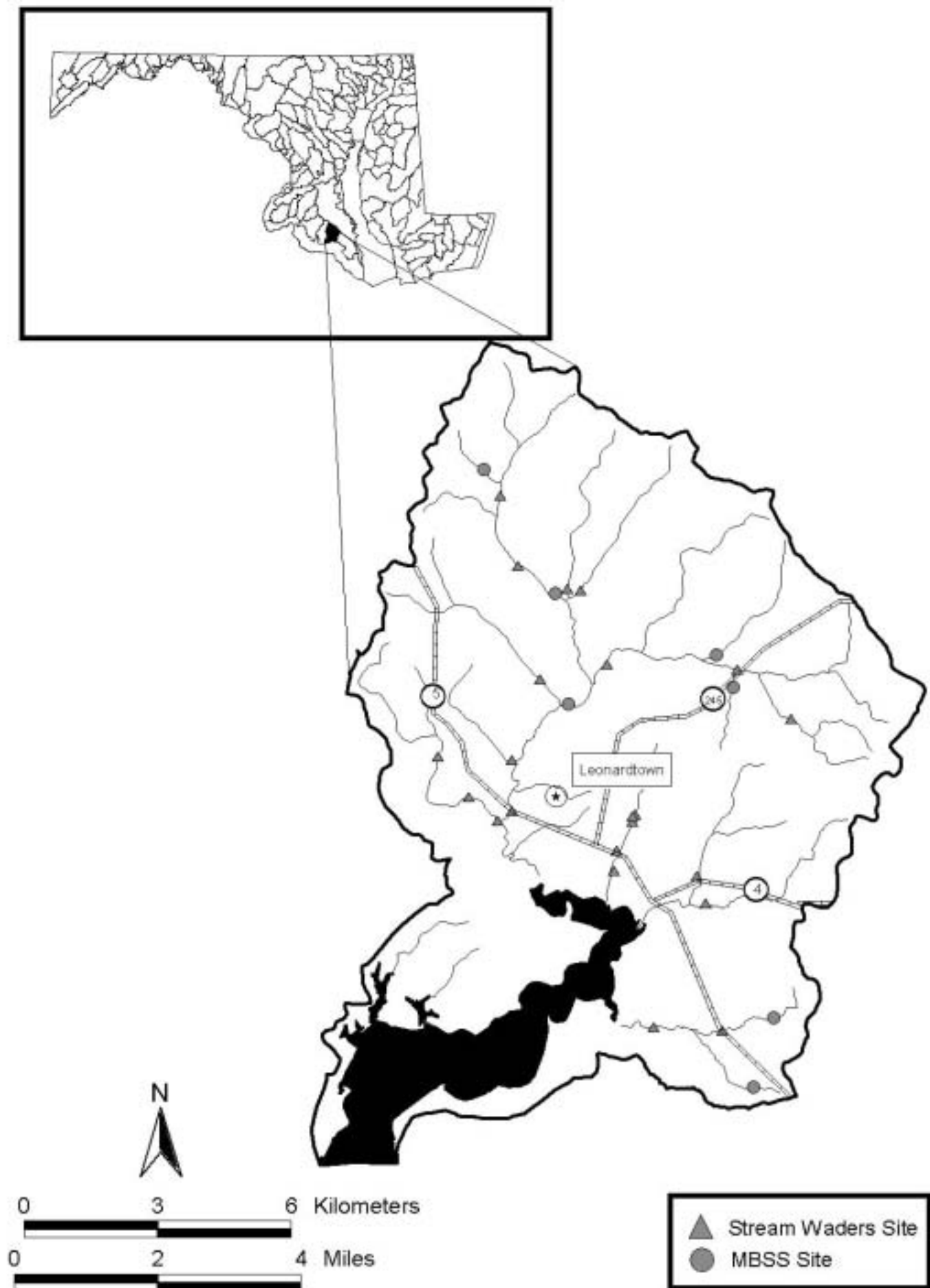


Figure 3. Sites sampled in Breton Bay watershed from 1995 to 2002.

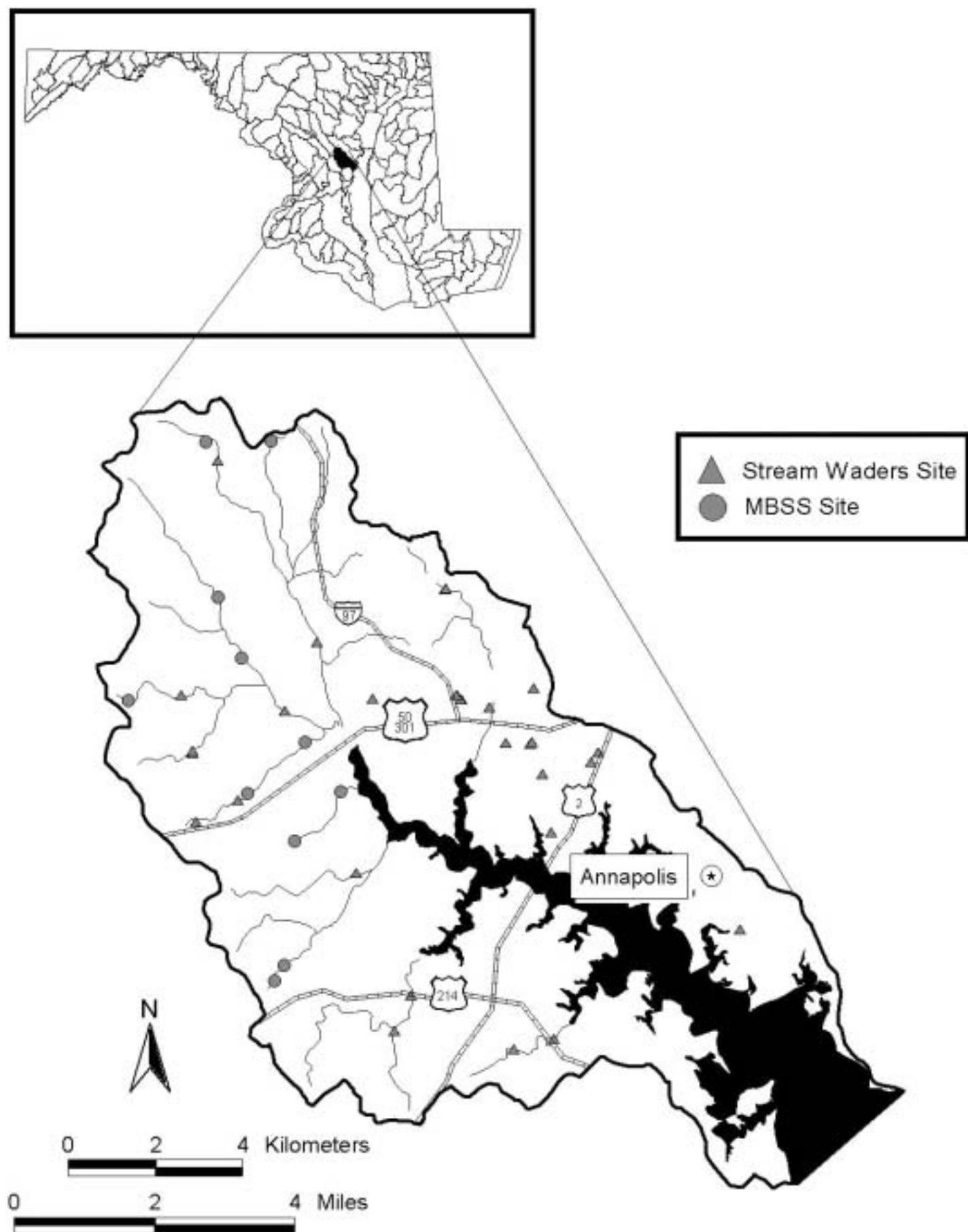


Figure 4. Sites sampled in South River watershed from 1995 to 2002.

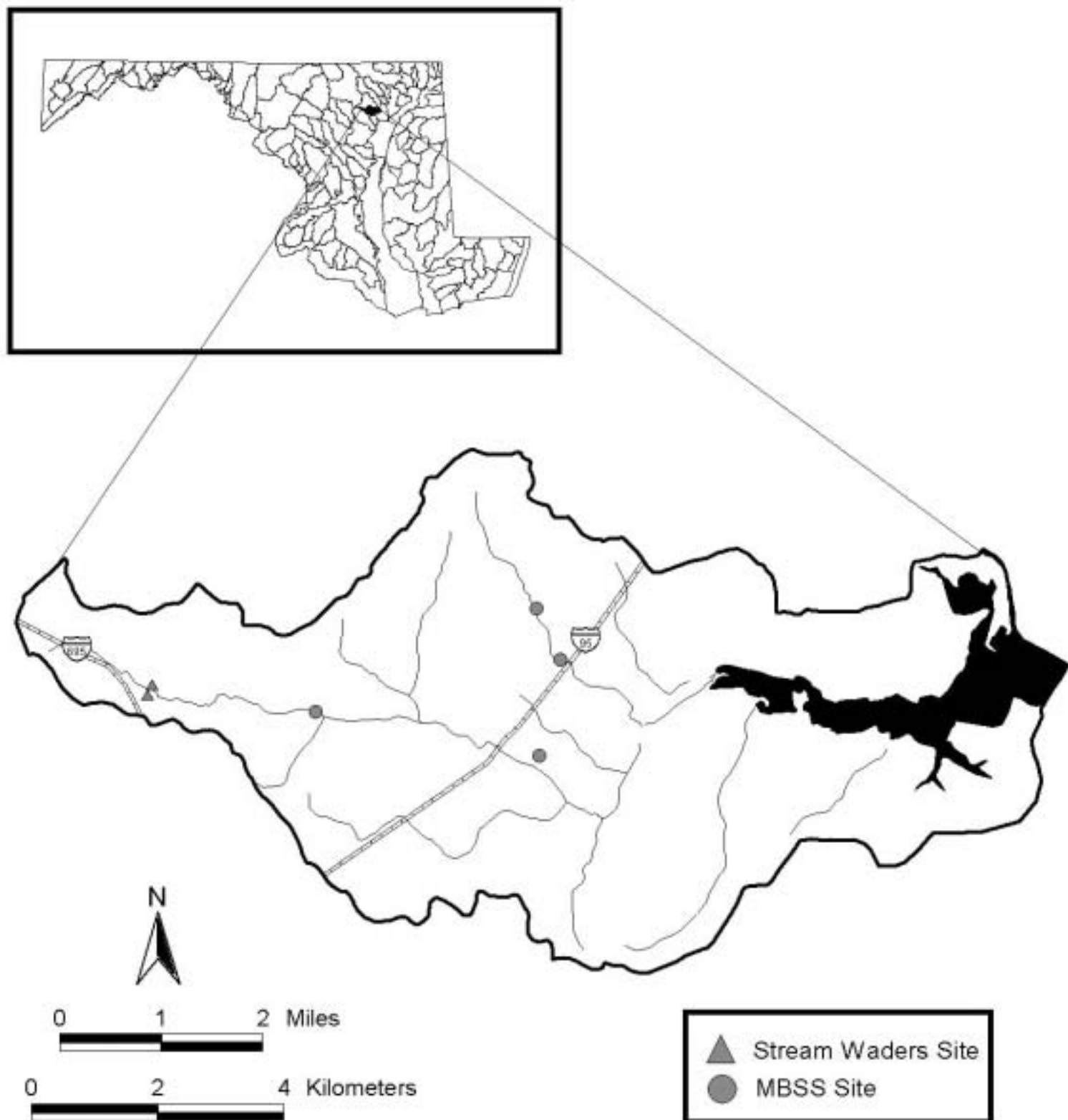


Figure 5. Sites sampled in Bird River watershed from 1995 to 2002.



Figure 6. Sites sampled in Lower Pocomoke watershed from 1995 to 2002.

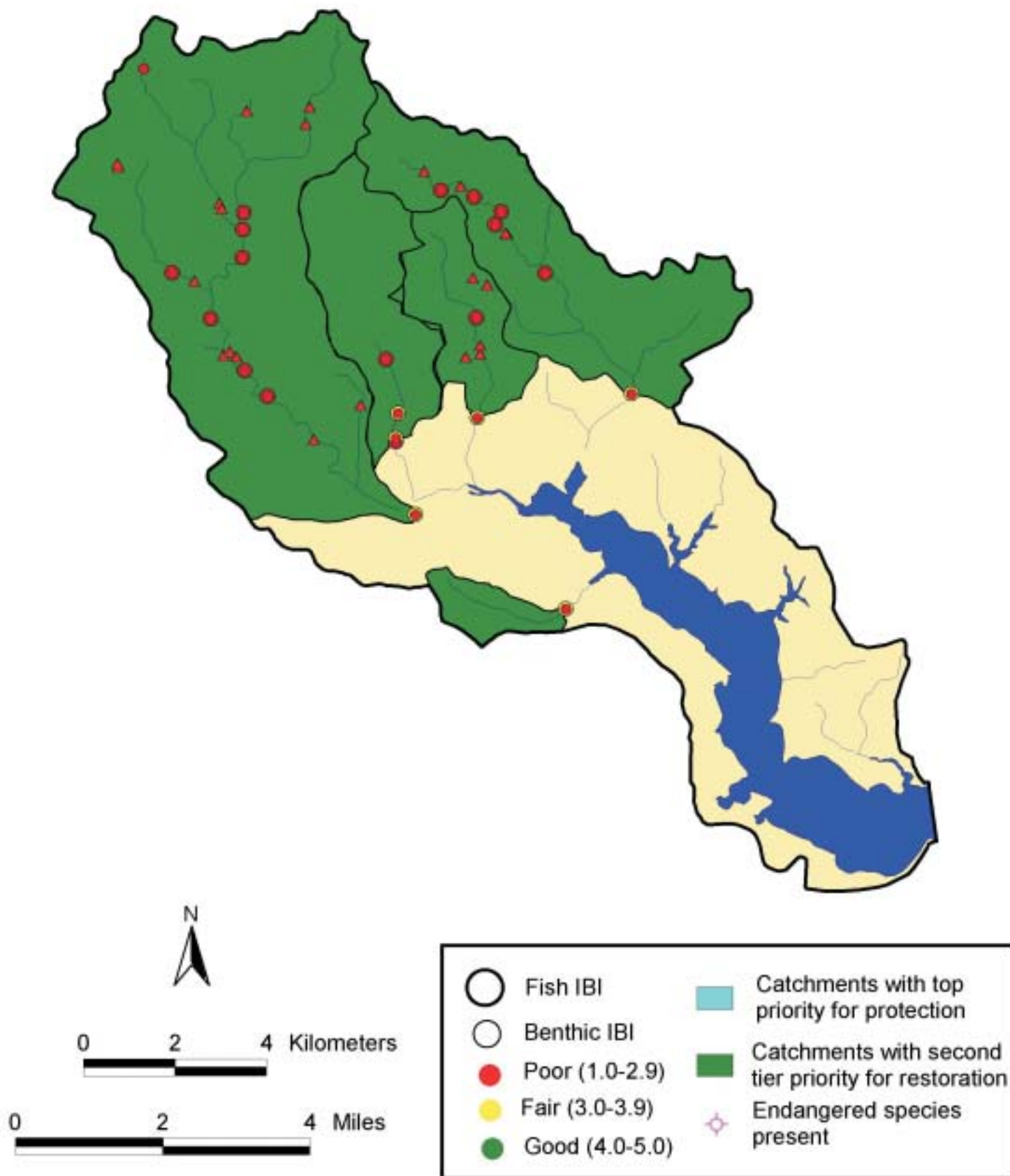


Figure 7. Areas in Back River watershed recommended for protection.

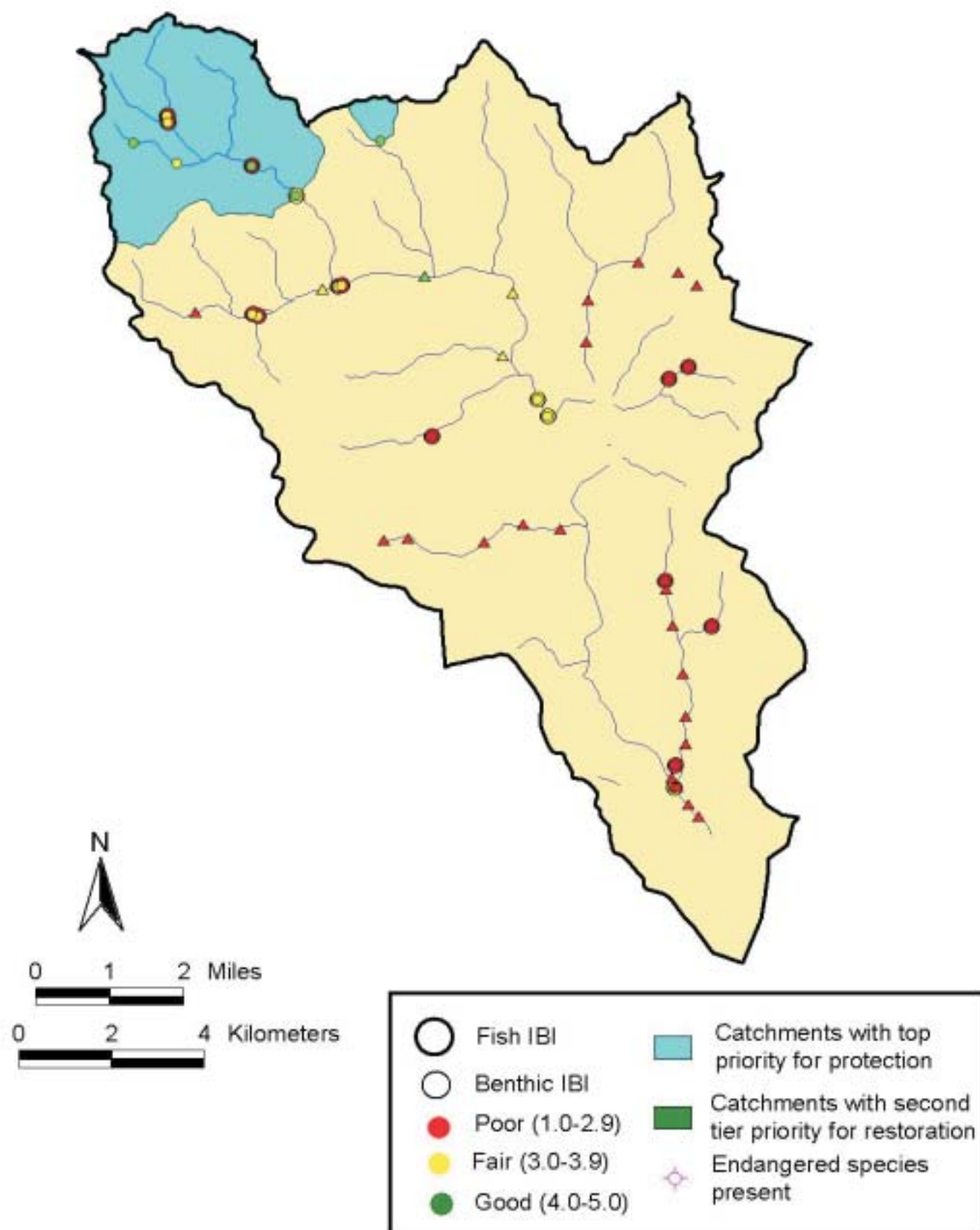


Figure 8. Areas in Jones Falls watershed recommended for protection.

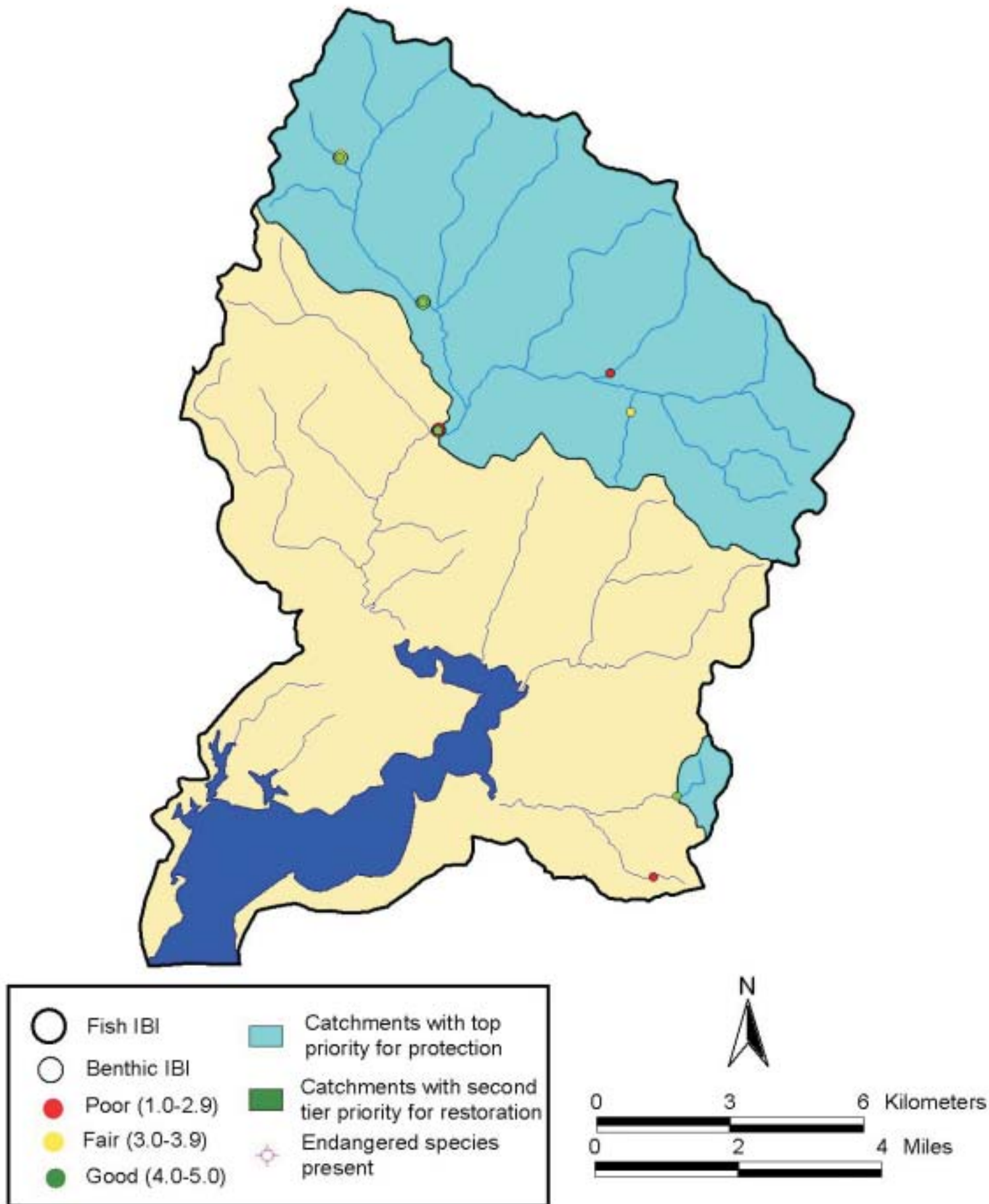


Figure 9. Areas in Breton Bay watershed recommended for protection.

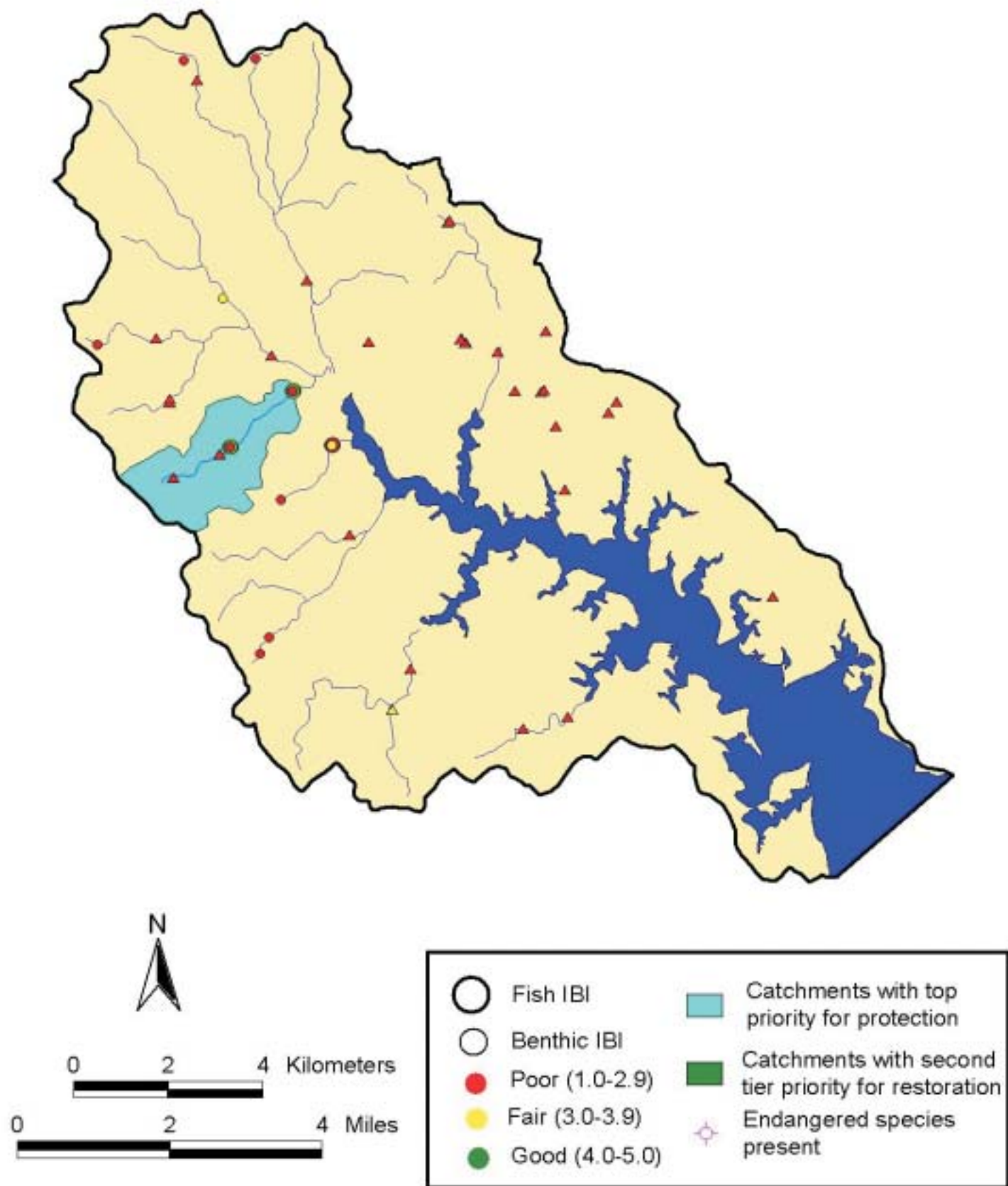


Figure 10. Areas in South River watershed recommended for protection.

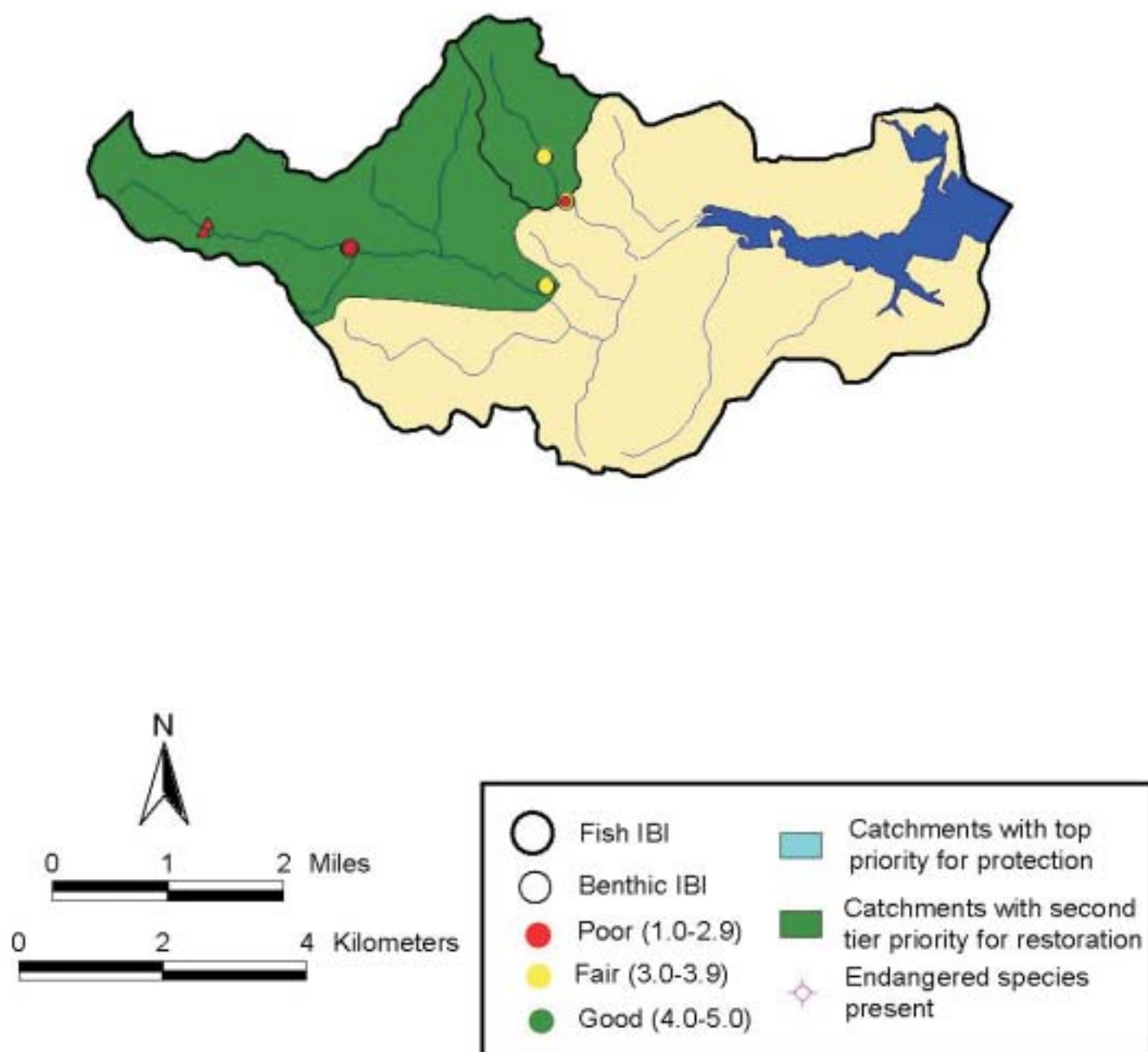


Figure 11. Areas in Bird River watershed recommended for protection.

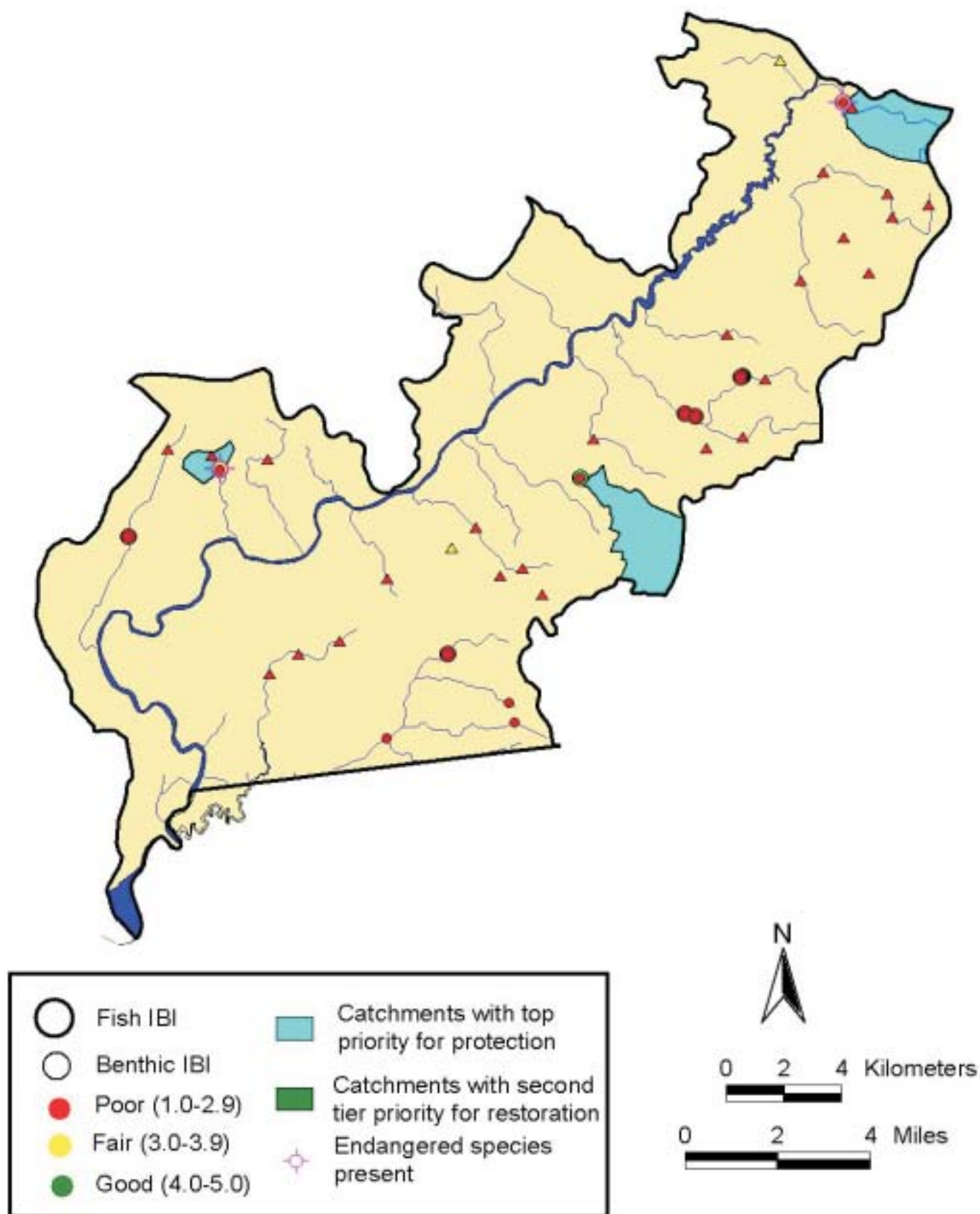


Figure 12. Areas in Lower Pocomoke watershed recommended for protection.

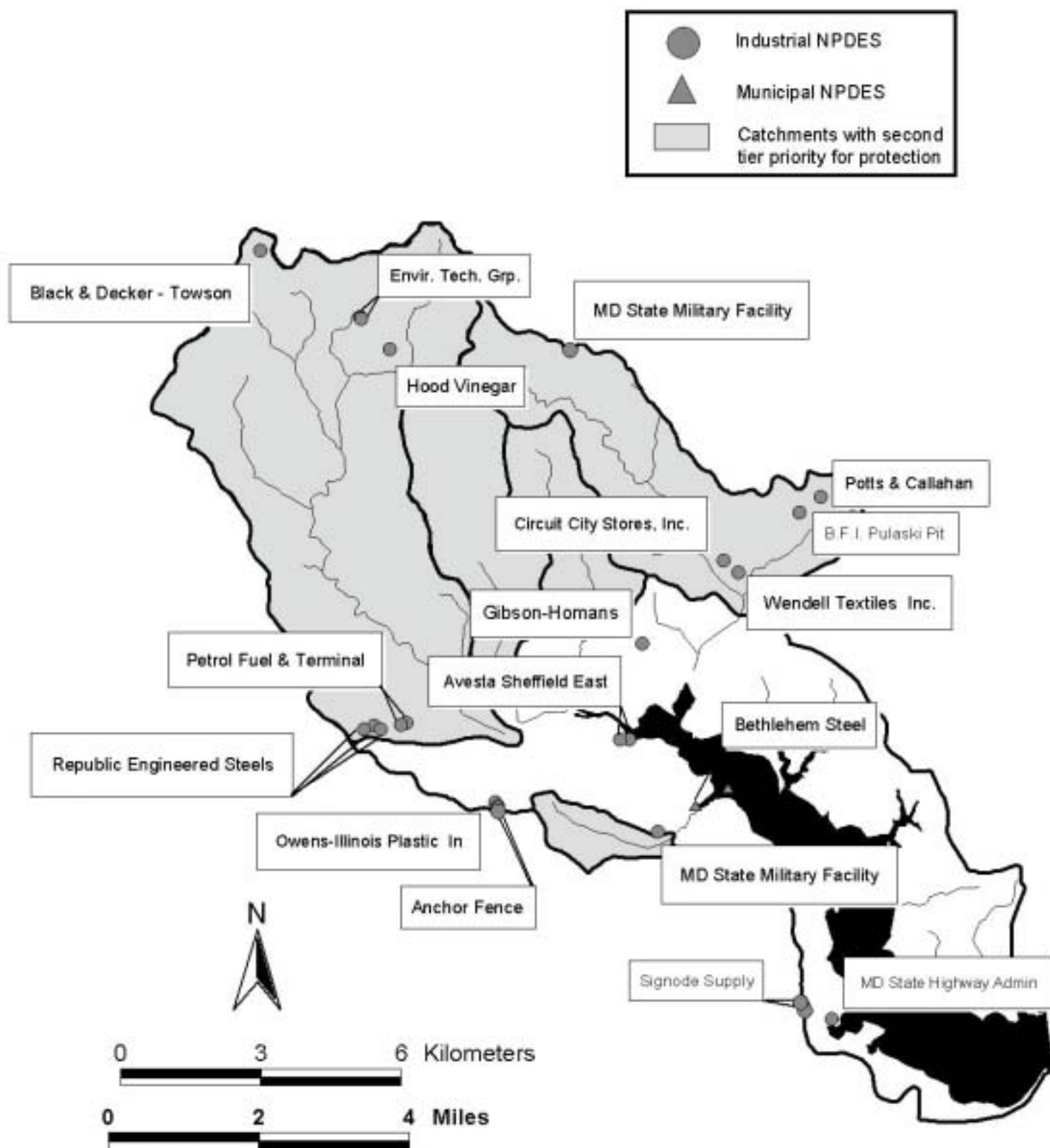


Figure 13. Municipal and Industrial NPDES sites in the Back River watershed.

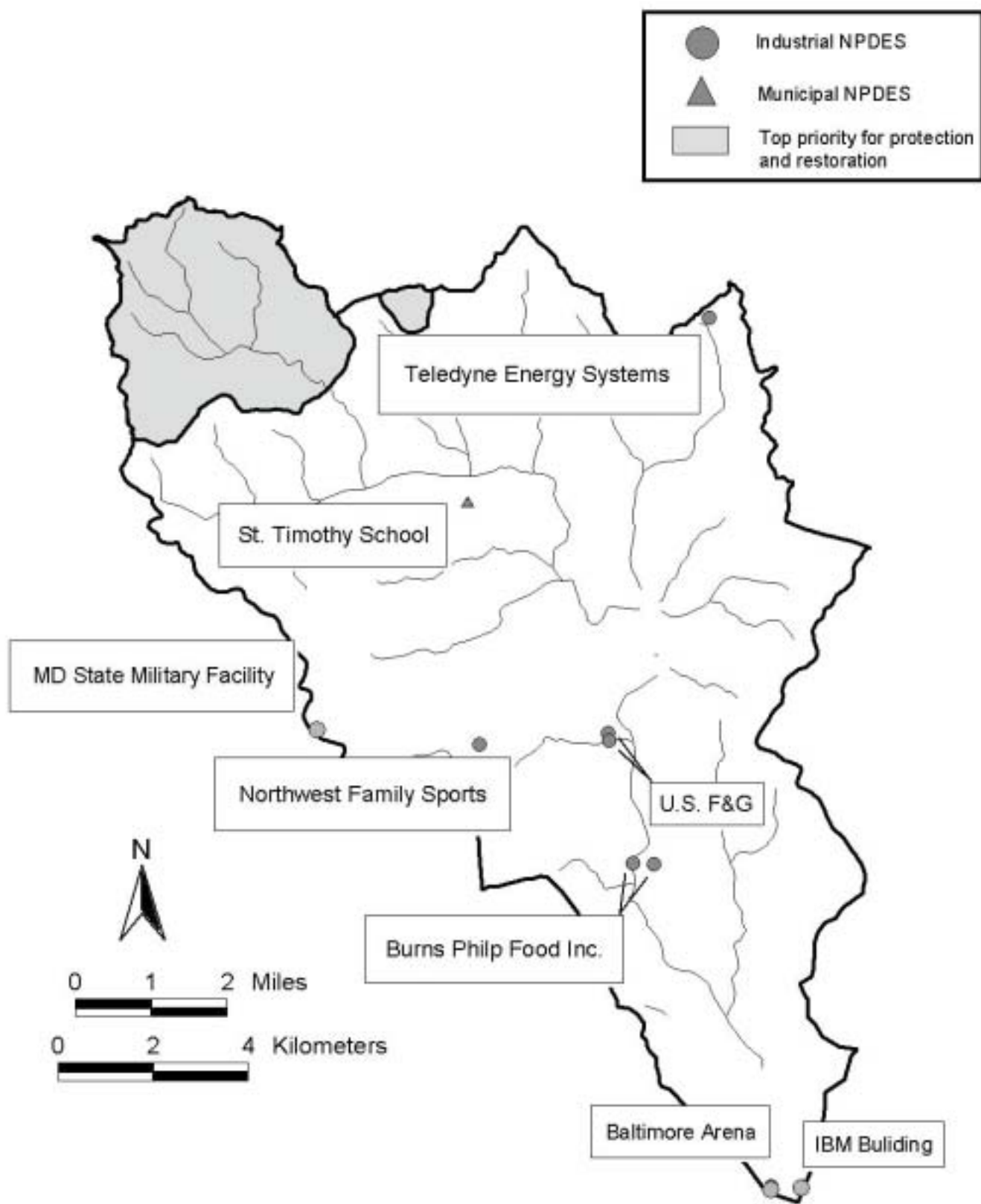


Figure 14. Municipal and Industrial NPDES sites in the Jones Falls watershed.

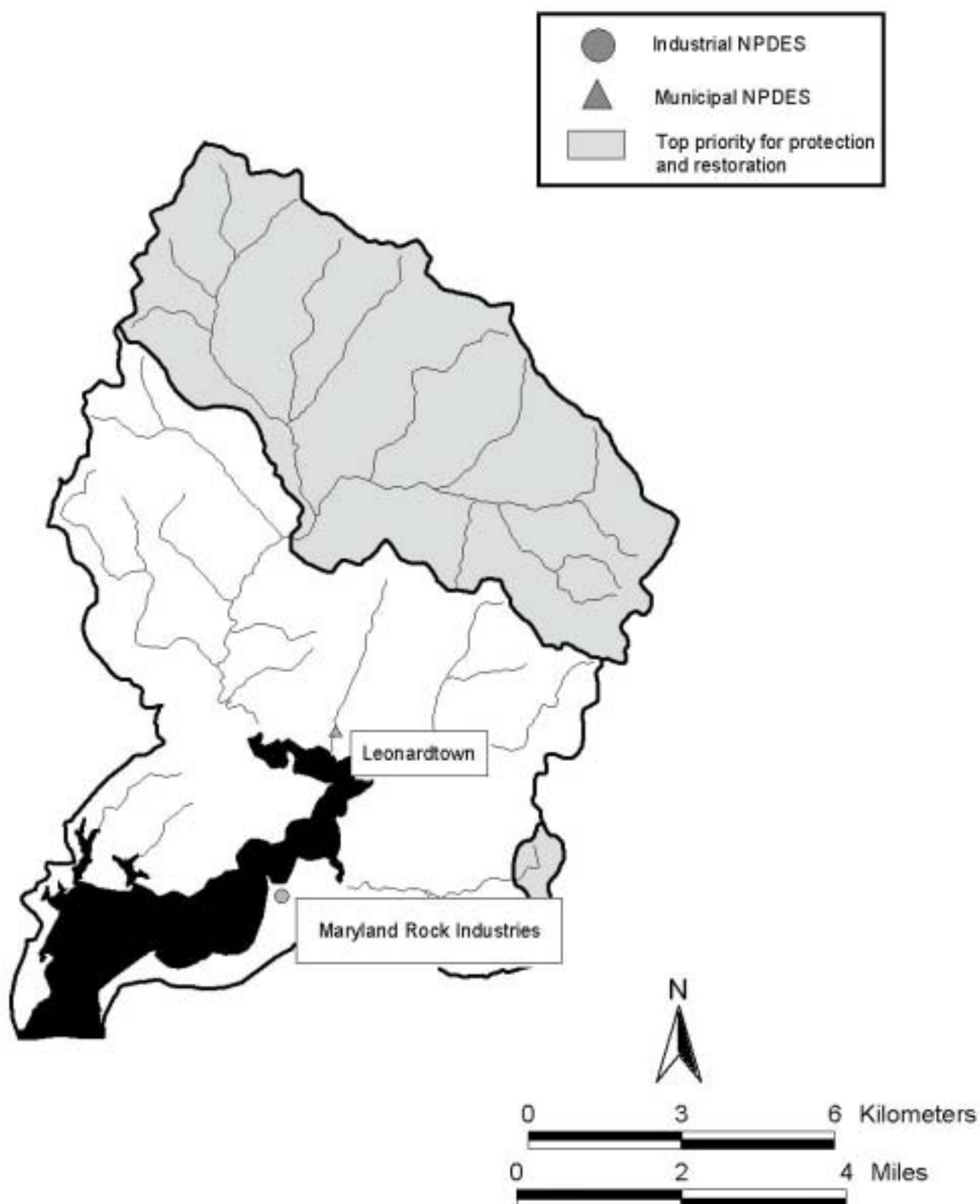


Figure 15. Municipal and Industrial NPDES sites in the Breton Bay watershed.

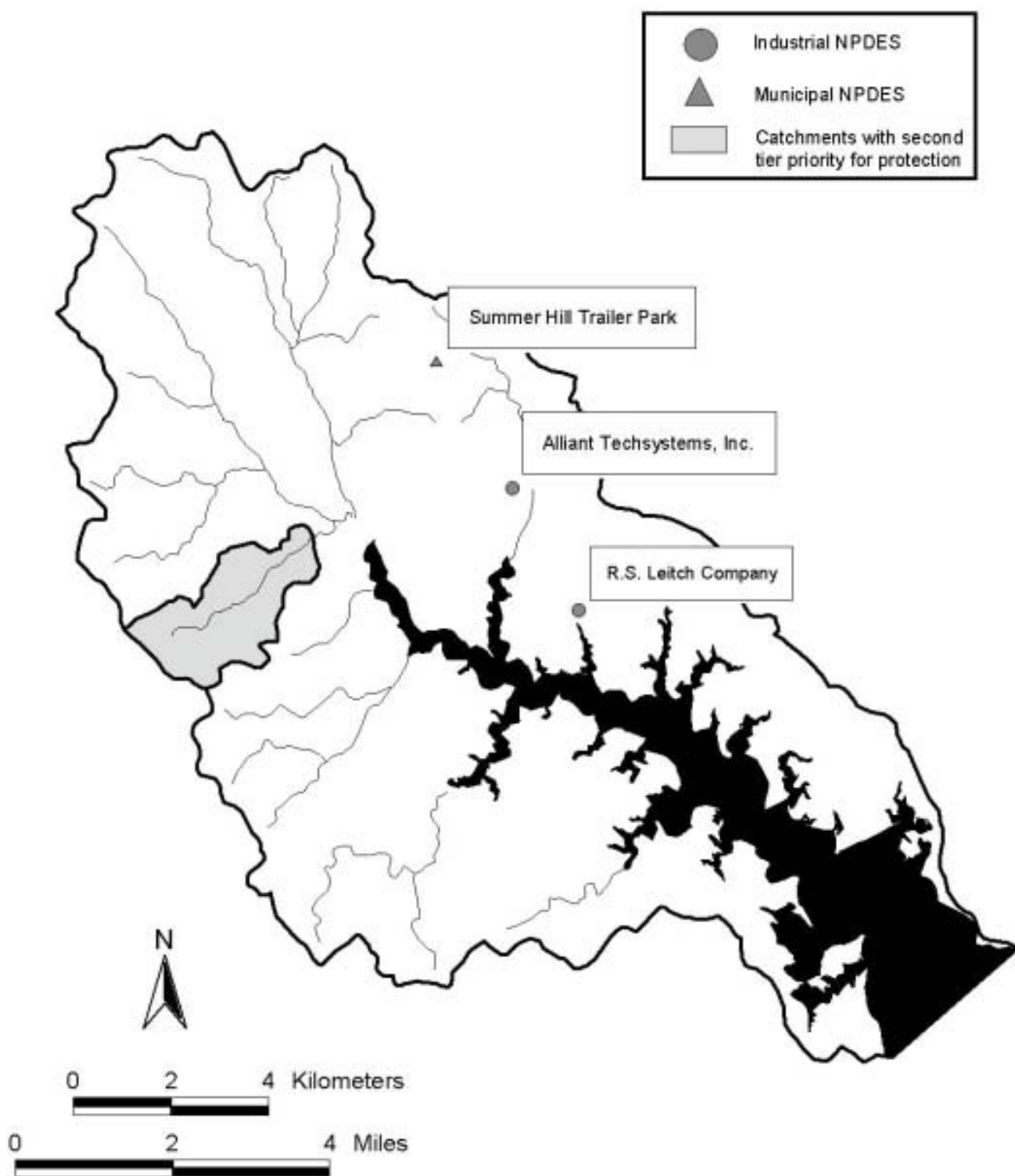


Figure 16. Municipal and Industrial NPDES sites in the South River watershed.

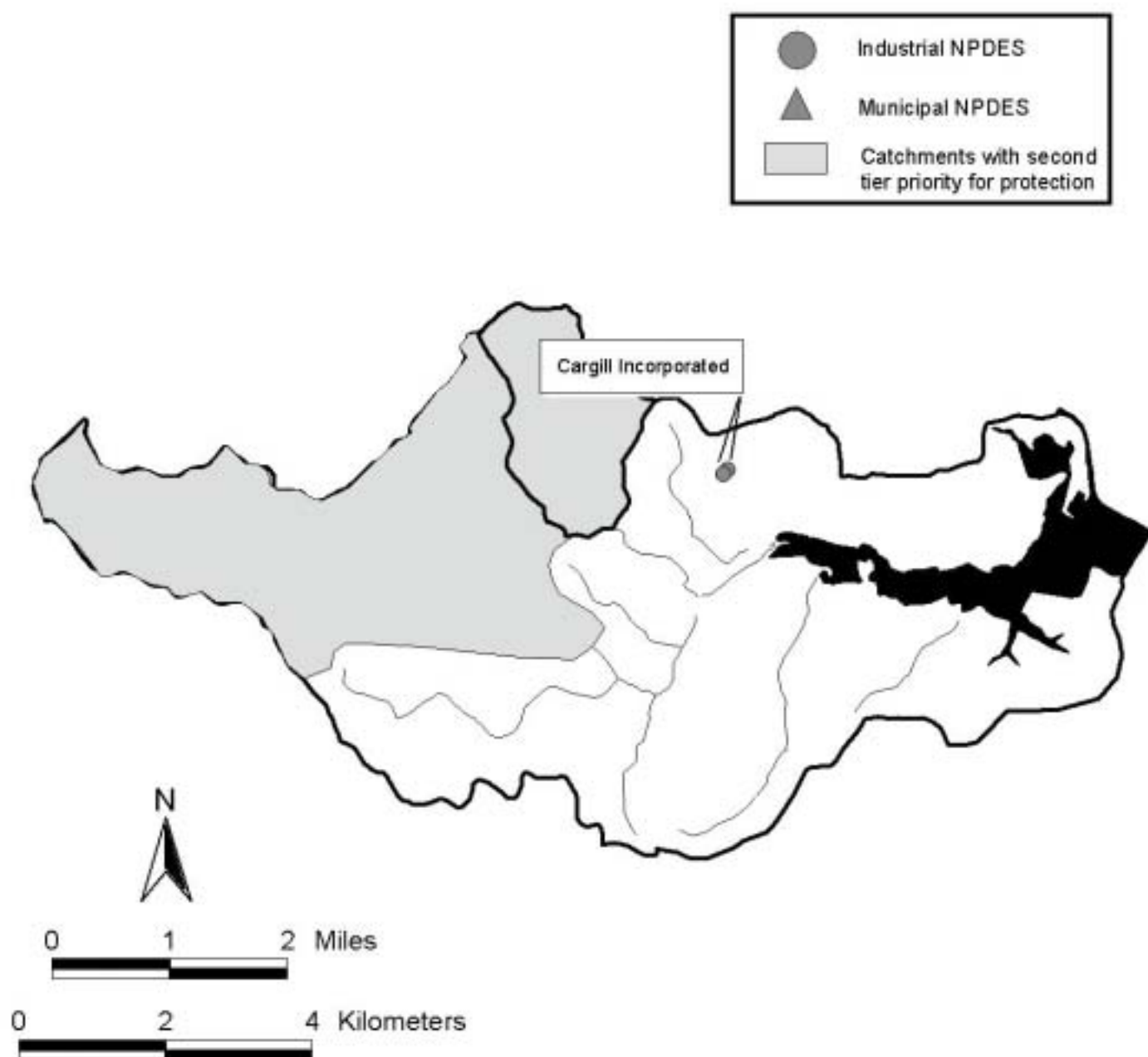


Figure 17. Municipal and Industrial NPDES sites in the Bird River watershed.

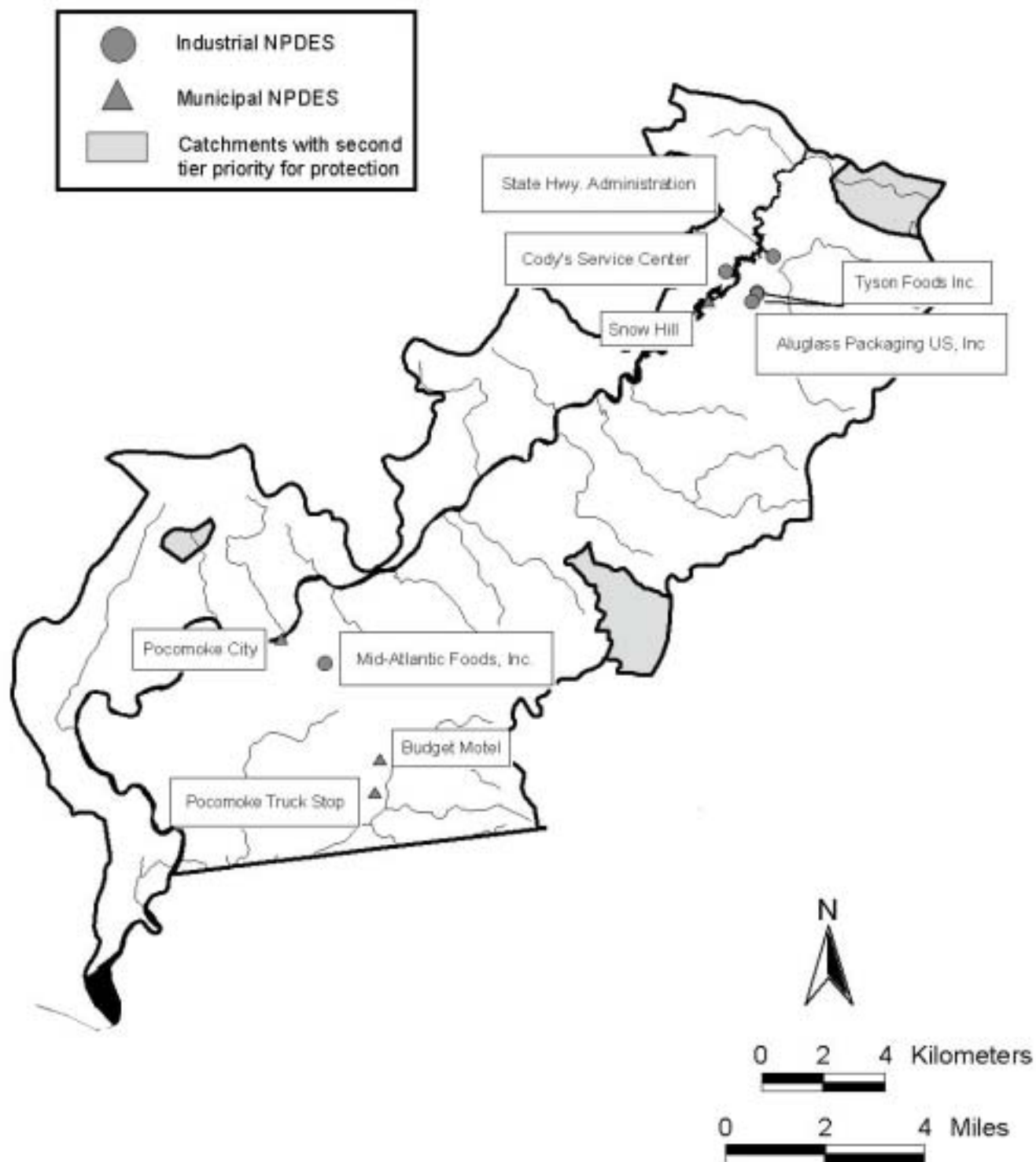


Figure 18. Municipal and Industrial NPDES sites in the Lower Pocomoke watershed.

**Appendix A:** Thresholds for classifying physical habitat, chemical, biological, and land use values as indicative of degradation or good quality, rare, or unique stream resources.

### **Biological Parameters**

**Fish IBI Score:** Fish Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10 <sup>th</sup> to 50 <sup>th</sup> percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if FIBI score is <3.0.

Site is outlined in bold if FIBI score is >4.0.

**Benthic IBI Score:** Benthic Index of Biotic Integrity, scored on the following scale:

Good	IBI Score 4.0-5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 3.0-3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally-impacted streams. Fall within the lower portion of the range of reference sites (10 <sup>th</sup> to 50 <sup>th</sup> percentile).
Poor	IBI Score 2.0-2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating some degradation.
Very Poor	IBI Score 1.0-1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally-impacted streams, indicating severe degradation.

Site is shaded if BIBI score is <3.0.

Site is outlined in bold if BIBI score is >4.0.

## **Water Quality Parameters**

**NO<sub>3</sub> Nitrate Nitrogen (mg/L):** Site is shaded if value is >10 mg/L, and outlined in bold if value is < 1.0 mg/L.

**D.O. Dissolved Oxygen (mg/L):** Site is shaded if value is ≤ 5 mg/L water criterion (COMAR 26.08.02).

**pH (units):** Site is shaded if value is ≤ 5.0. pH less than 5.0 is considered harmful to stream biota, especially fish (COMAR 26.08.02).

**SO<sub>4</sub> Sulfate (mg/L):** Site is shaded if value is ≥ 50 mg/L.

**Temperature (°C):** Site is shaded if value exceeds the temperature criteria for Use Class I waters (32°C). All streams in the watersheds discussed in this report are Use Class I.

**Turbidity (NTUs):** Site is shaded if value is ≥ 10 NTUs.

## **Physical Habitat Parameters:**

**Physical habitat variables include the following:**

**Instream Habitat:** Scored based on the value of instream habitat available to the fish community.

**Epifaunal Substrate:** Scored based on the amount and variety of hard, stable substrates used by benthic macroinvertebrates.

**Velocity/Depth Diversity:** Scored based on the variety of velocity/depth regimes present at a site.

**Pool/Glide/Eddy Quality:** Scored based on the variety and complexity of slow or still water habitat present at a site.

**Bank Stability:** Scored based on the stability of stream banks and potential for erosion at a site.

Site is shaded if a score for any physical habitat variable is ≤ 6, and outlined in bold if the score is > 16.

**Eroded Bank Area (m<sup>2</sup>):** Site is shaded if value is > 75 meters. Site is and outlined in bold if value = 0 meters.

**Erosion Severity Score:** Severity of erosion on both stream banks. Site is shaded if value is  $\geq 2.5$ , and outlined in bold if value is 0.

**Embeddedness:** Site is shaded in if value is 100 percent and outlined in bold if value is 0 percent.

### **Land Use Parameters**

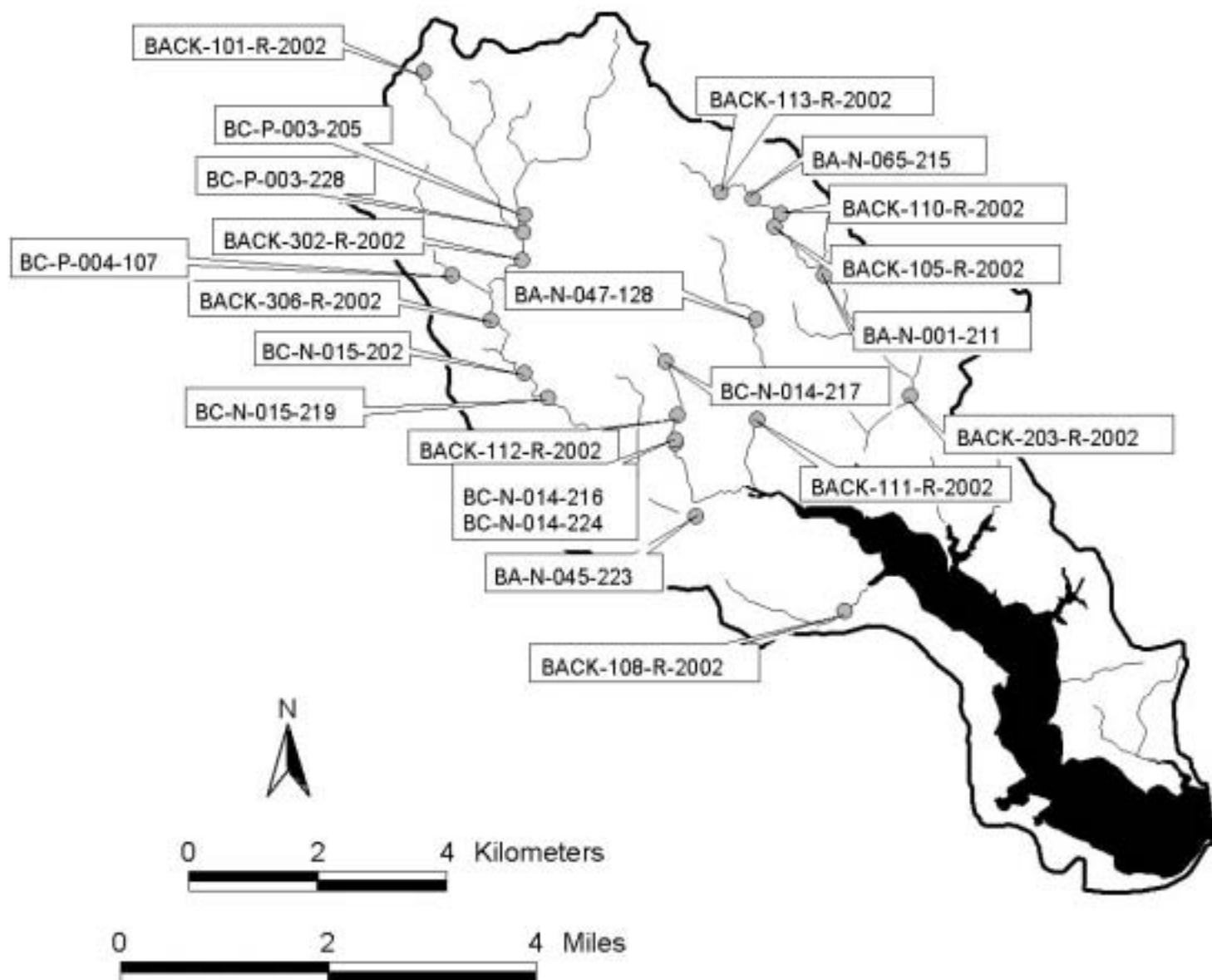
**Riparian Buffer Width:** Site is shaded if buffer width is  $< 10$  meters and outlined in bold if width is  $\geq 50$  meters.

**Agricultural Land Use:** Site is shaded if value is  $\geq 75$  percent.

**Urban Land Use (%):** Site is shaded if value is  $> 50$  percent and outlined in bold if value is  $\leq 20$  percent.

**Impervious Land Cover:** Site is shaded if value is  $> 10$  percent, and outlined in bold if value is  $< 2$  percent.

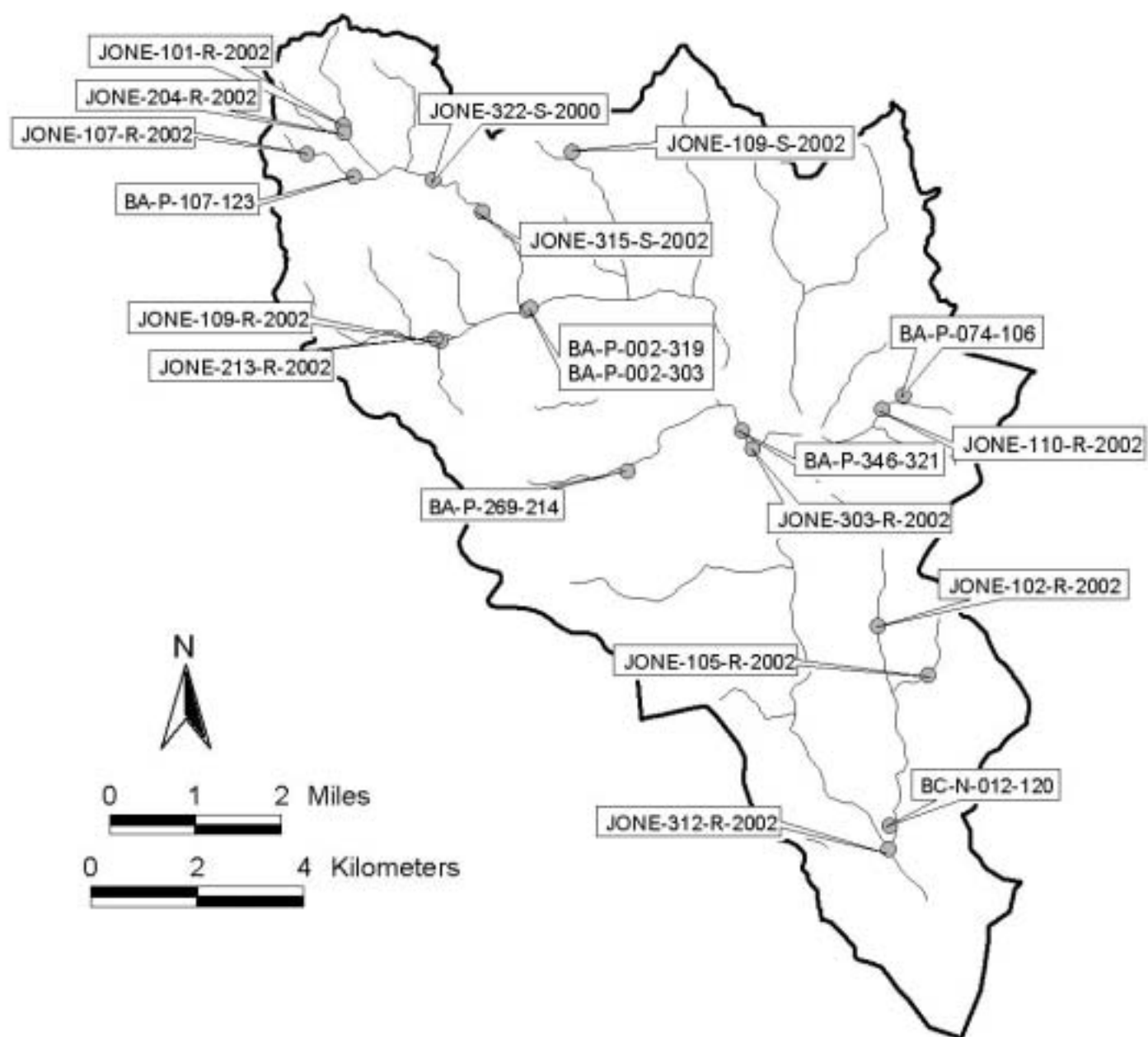
Appendix B  
Locations of Stream Waders and Maryland Biological Stream Survey Sites



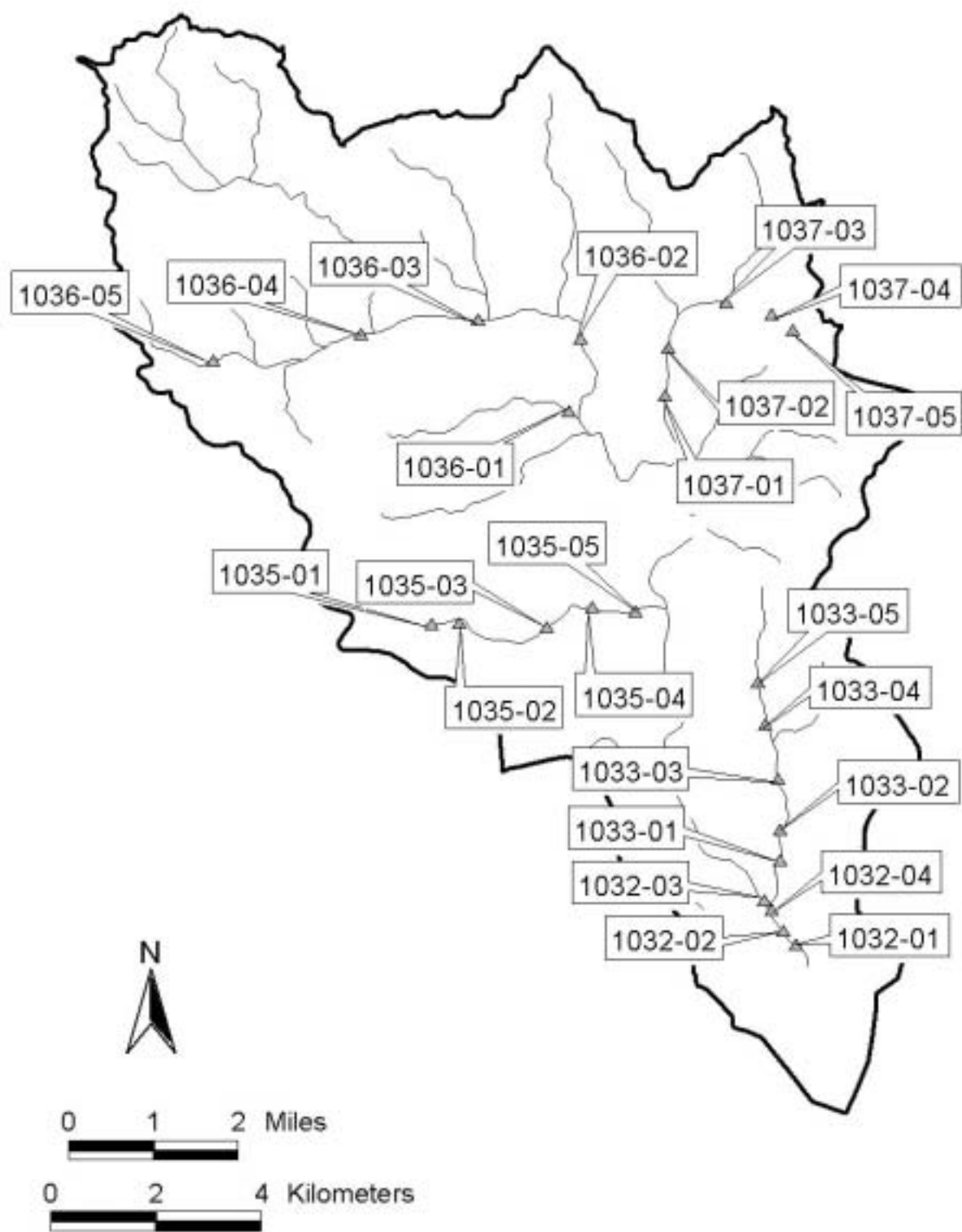
MBSS site names and location in Back River watershed sampled in 1995, 1996 and 2002.



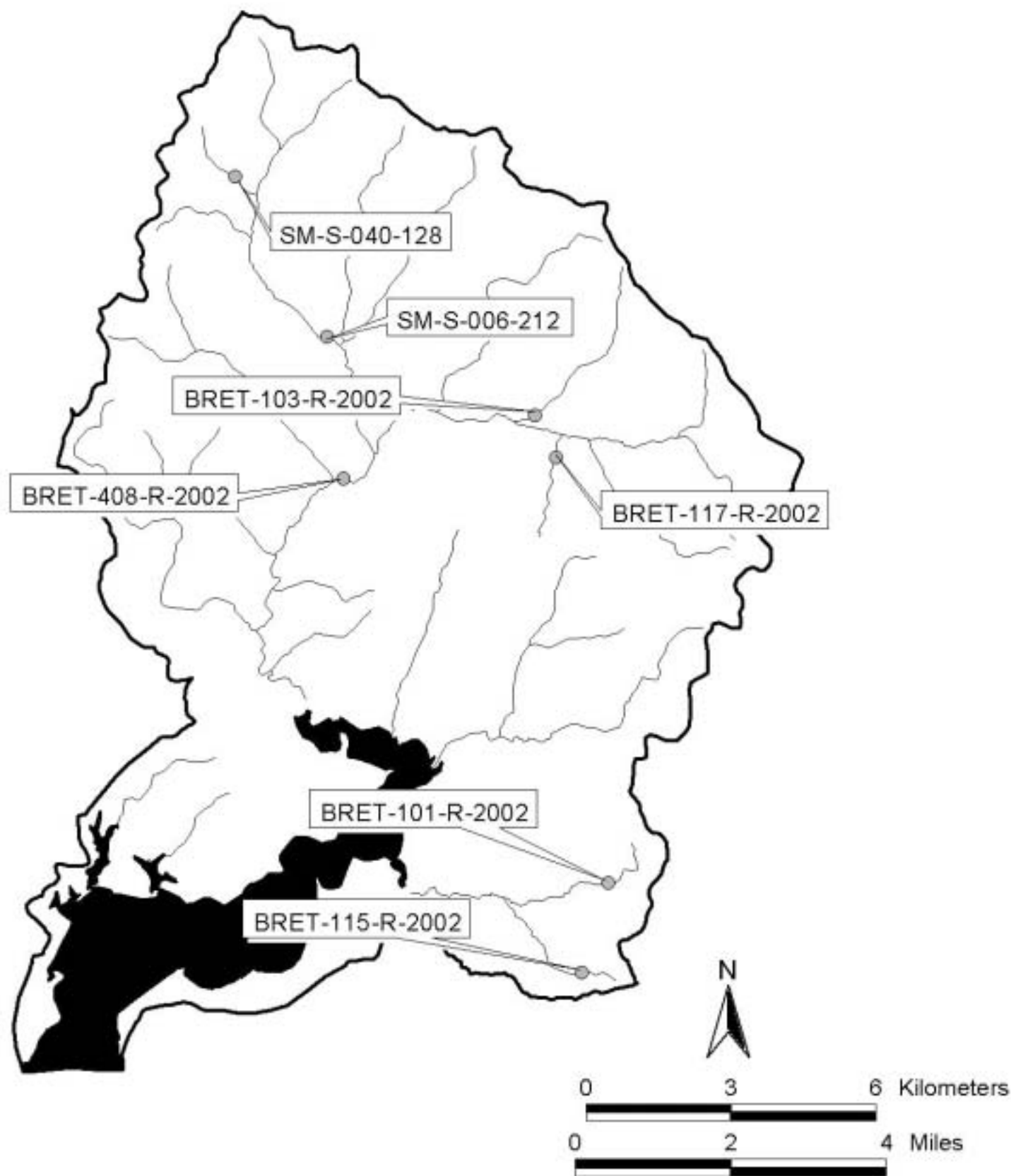
Stream Waders site names and locations in Back River watershed sampled in 2002.



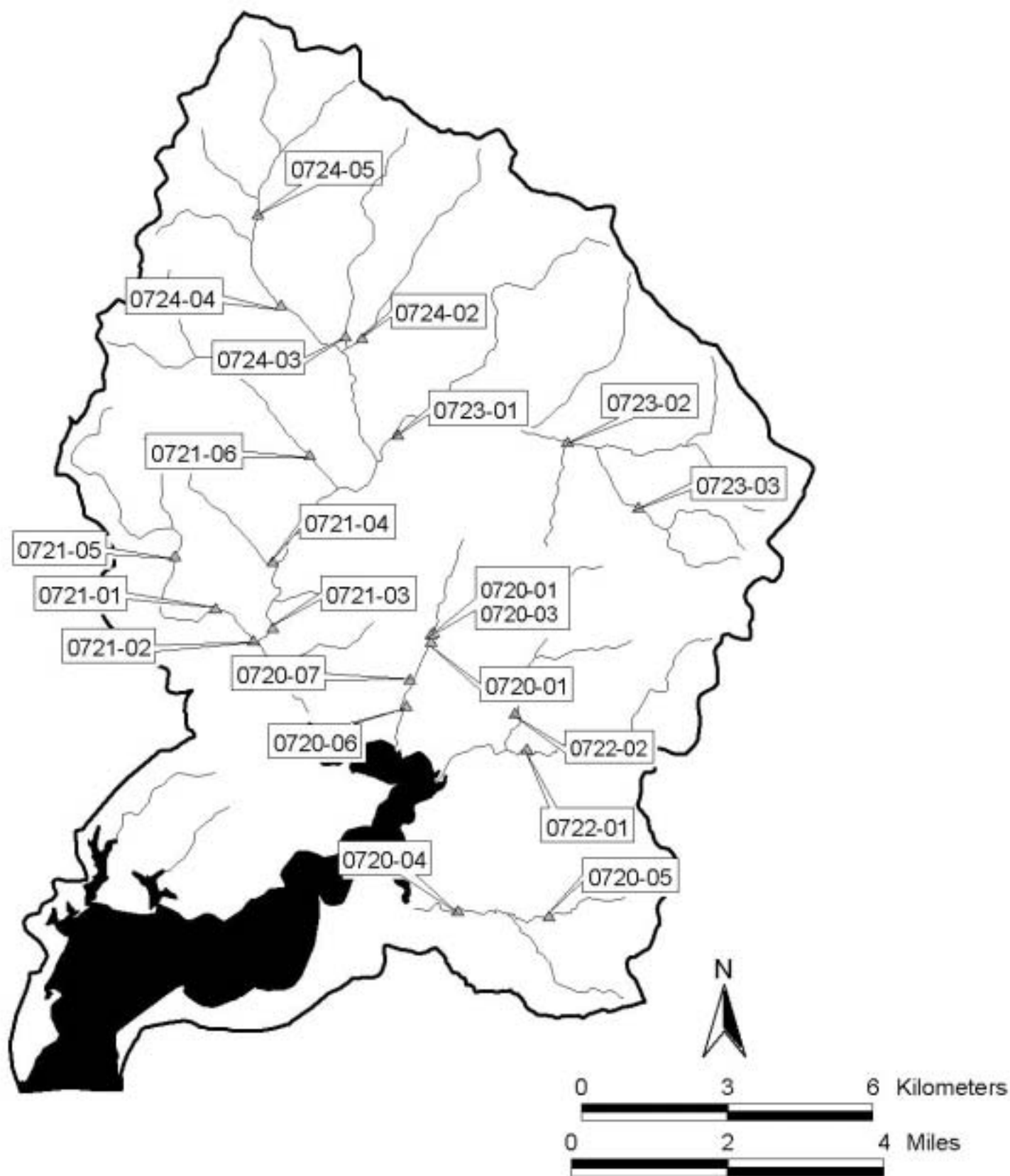
MBSS site names and locations in Jones Falls watershed sampled in 2000, 2001, and 2002.



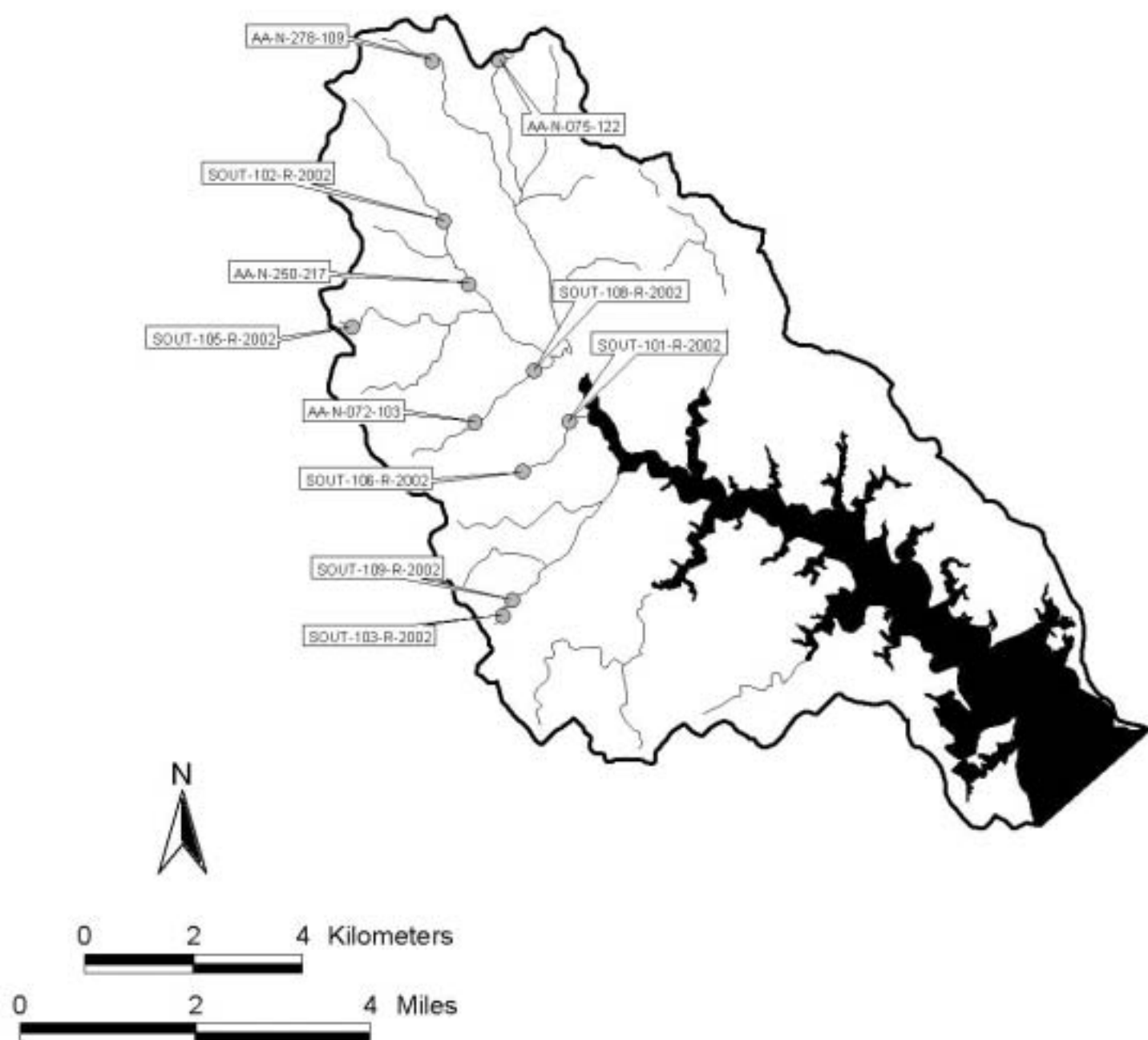
Stream Waders names and locations in Jones Falls watershed sampled in 2002.



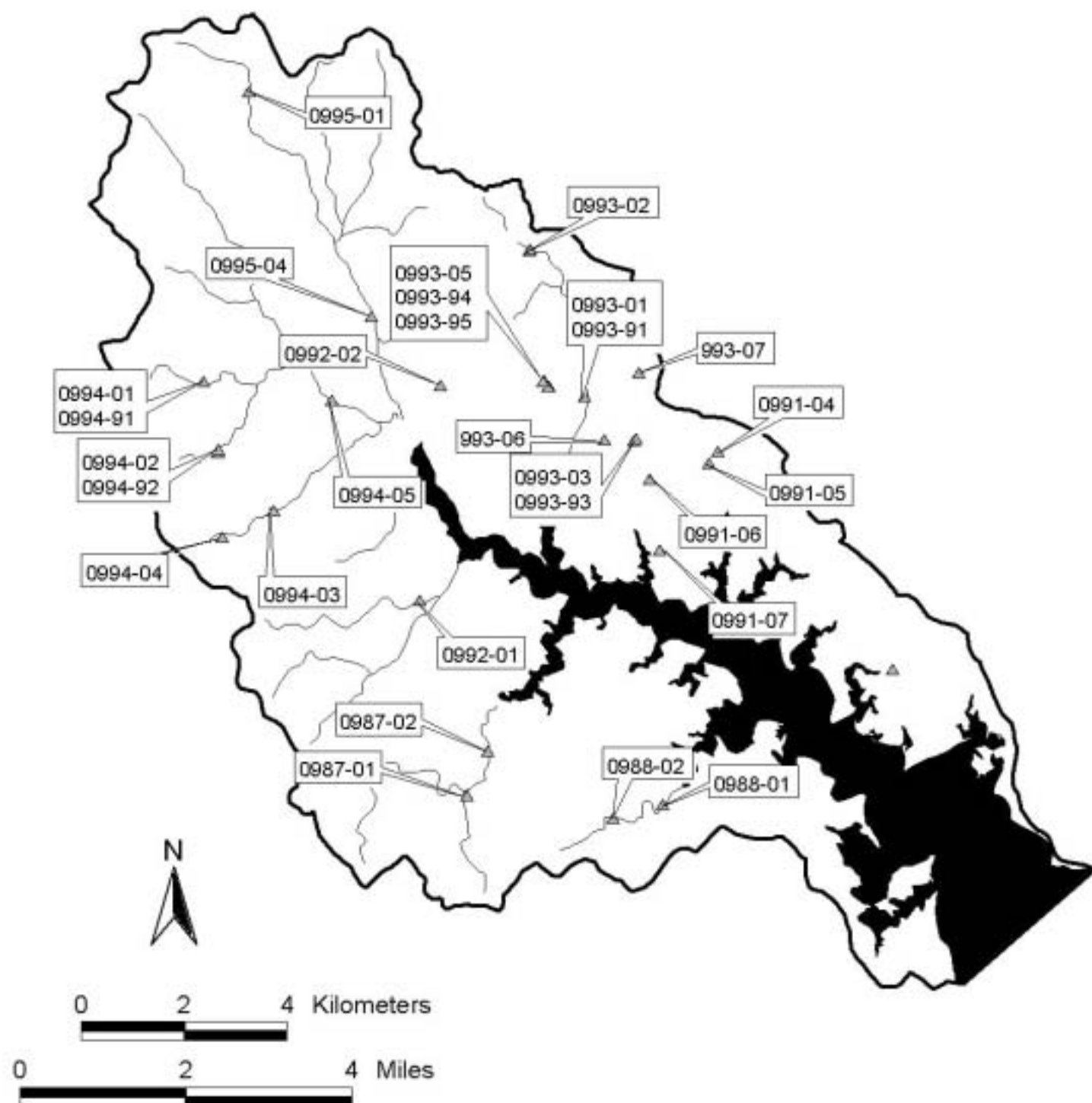
MBSS site names and locations in Breton Bay watershed sampled in 1995 and 2002.



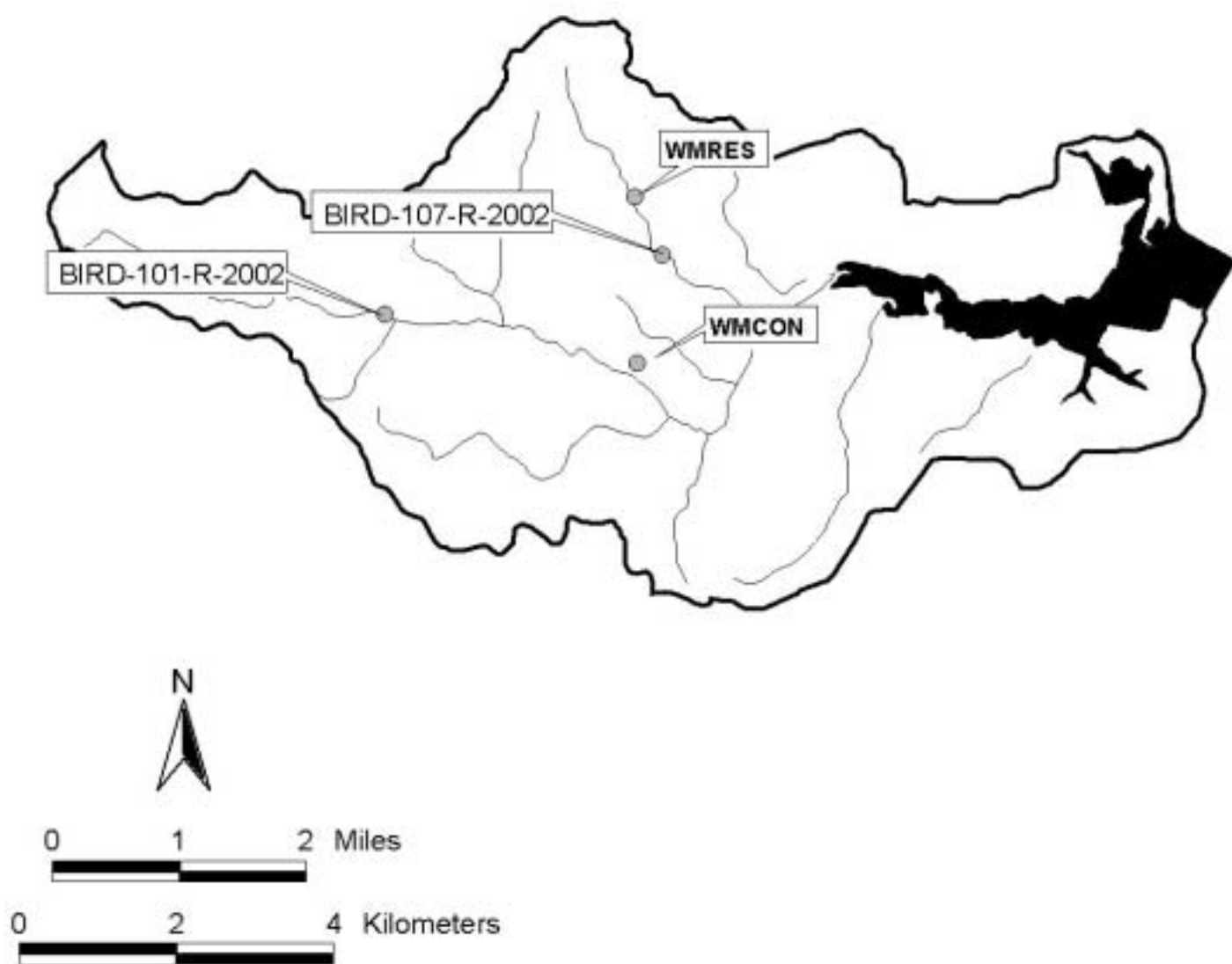
Stream Waders site names and locations in Breton Bay watershed sampled 2002.



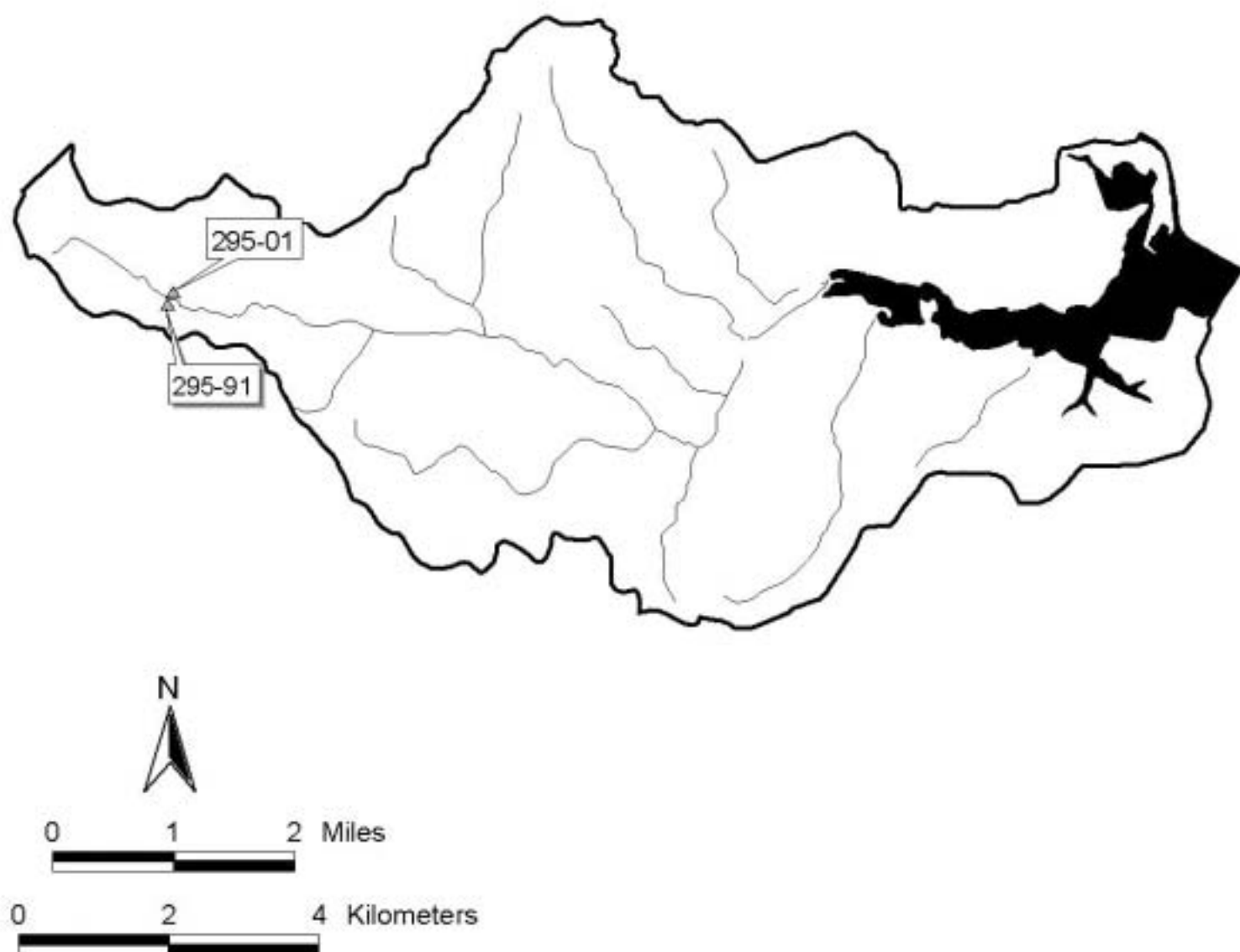
MBSS site names and locations in South River watershed sampled in 1997 and 2002.



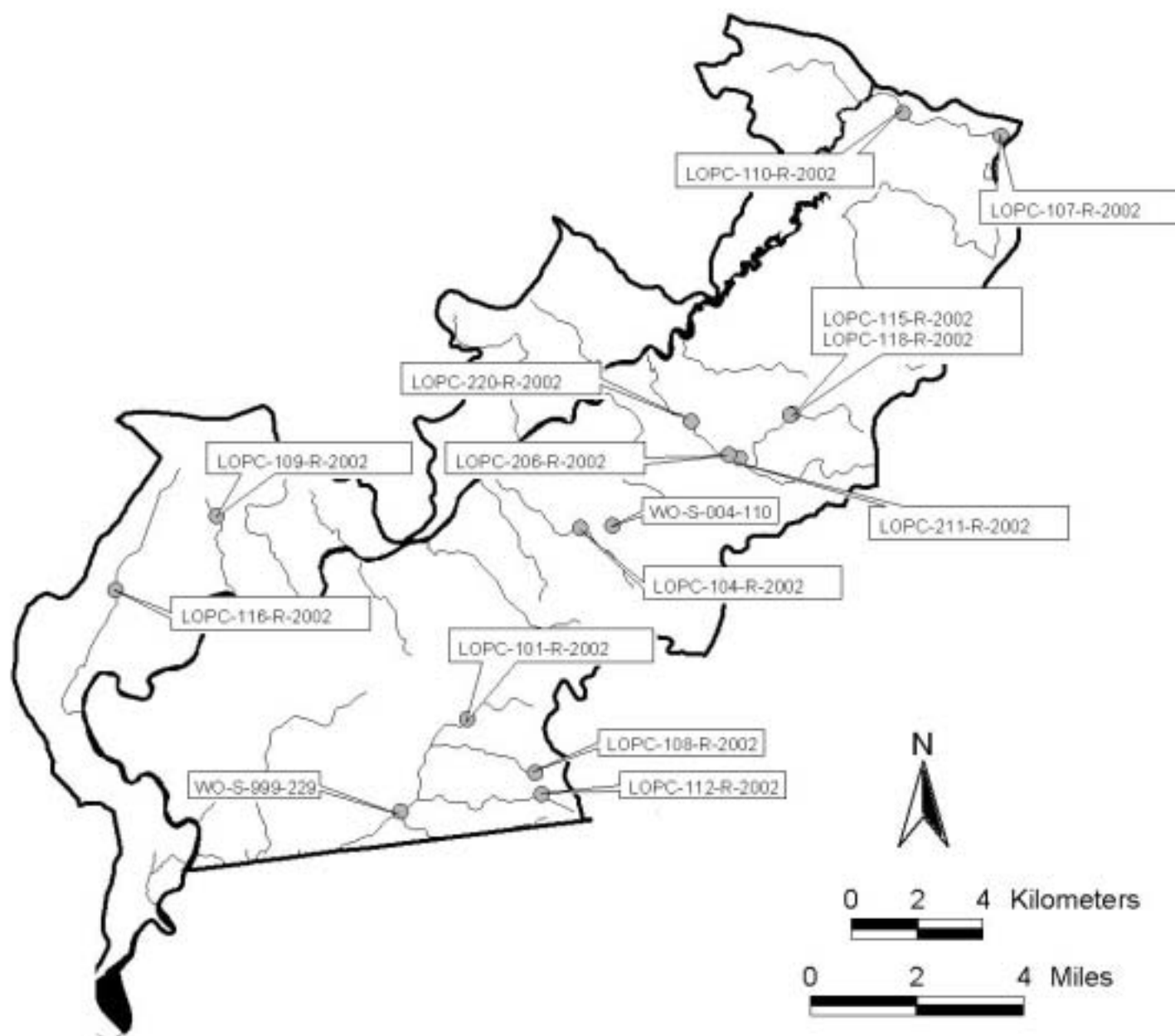
Stream waders site names and locations in South River watershed sampled in 2002.



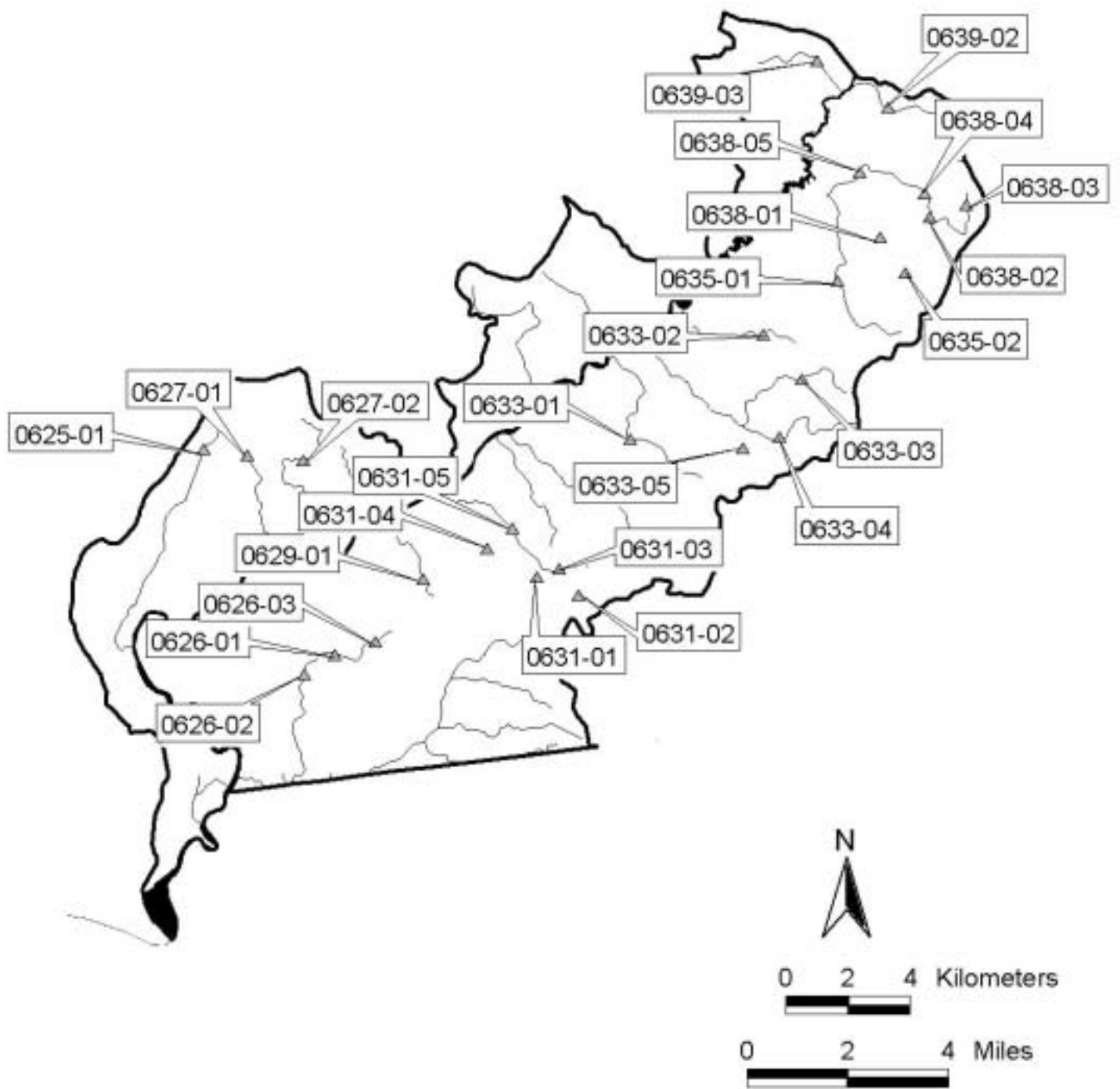
MBSS site names and locations in Bird River watershed sampled in 2002.



Stream Waders site names and locations in Bird River watershed sampled in 2002.



MBSS site names and locations in the Lower Pocomoke watershed sampled in 1997 and 2002.



Stream Waders site names and locations in Lower Pocomoke watershed sampled in 2002.